

ENVIRONMENT

Richborough
Land North of A47 Normandy Way and
West of A447 Ashby Road
Hinckley
Flood Risk Assessment

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March 2024

DOCUMENT ISSUE RECORD

Document Number:	HN2-BWB-ZZ-XX-RP-YE-0002_FRA
BWB Reference:	232746_FRA

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Rev	Date	Status	Comment	Author:	Checked:	Approved:
P01	27/09/23	S2	Preliminary Issue	LR	MB	AP
P02	16/11/23	S2	Red line boundary and masterplan amended	LR	MB	MB
P03	18/01/24	S2	Red line boundary, development description and masterplan amended only	SR	LR	RM
P04	07/03/24	S2	Red line boundary, development description and masterplan amended only	SR	LR	RM

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EXECUTIVE SUMMARY

This Flood Risk Assessment (FRA) has been prepared in accordance with the requirements set out in the National Planning Policy Framework (NPPF) and the associated Planning Practice Guidance. It has been produced on behalf of Richborough in respect of a planning application for a proposed residential development on Land North of A47 Normandy Way and West of A447 Ashby Road, Hinckley (approximate grid reference: SP426958).

This report demonstrates that the proposed development is not at significant flood risk, subject to the recommended flood mitigation strategies being implemented.

The site is located entirely within Flood Zone 1 (Low Probability). The nearest EA Flood Extents are located approximately 1.6km north of the site, attributed to the River Tweed. An Unnamed Ordinary Watercourse (UOW) is shown to flow adjacent to the western boundary of the site, and outfalls to the River Tweed approximately 2.0km downstream of the site. The UOW is not represented on the EA's Flood Map for Planning due to its small draining catchment area (<3km²).

To provide a detailed understanding of the fluvial flood risk posed to the site from the UOW, BWB Consulting Ltd completed a hydraulic modelling study in April 2022. The model was updated in July 2023 to ensure modelled flows are in accordance with current best-practice hydrological methods. The updated hydraulic model outputs show that flows remain in channel for all simulated return periods adjacent to the site. Therefore, the proposed residential development is sequentially located outside of all modelled flood extents from the UOW.

To ensure the development is safe for its lifetime, it is recommended that finished floor levels are raised a minimum of 600mm above the modelled 1 in 100-year +22%CC peak flood level.

The proposed development has been reviewed against other potential sources of flood risk including canals, surface water, groundwater, reservoirs and large waterbodies and sewers. None of these flood sources have been found to represent a potential barrier to development.

To mitigate the residual risk of flooding it is recommended that as a minimum finished floor levels are raised 150mm above surrounding ground levels and ground levels should be profiled to encourage pluvial runoff and overland flows away from built development and towards the nearest drainage point.

To mitigate the development's impact on the current runoff regime, it is proposed to incorporate surface water attenuation and storage as part of the development proposals. It is proposed to drain foul water from the development separately to surface water.

In compliance with the requirements of the NPPF, and subject to the mitigation measures proposed, the development could proceed without being subject to significant flood risk. Moreover, the development will not increase flood risk to the wider catchment area subject to suitable management of surface water runoff discharging from the site.

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1. INTRODUCTION

- 1.1 This Flood Risk Assessment (FRA) has been prepared in accordance with the requirements set out in the National Planning Policy Framework (NPPF) and the associated Planning Practice Guidance (PPG). The FRA has been produced on behalf of Richborough in respect of a planning application for a proposed residential development on Land North of A47 Normandy Way and West of A447 Ashby Road, Hinckley.
- 1.2 This FRA is intended to support an outline planning application with all matters reserved except for access, for the erection of up to 415 dwellings, associated open space, drainage, landscaping and infrastructure. The level of detail included is commensurate and subject to the nature of the proposals at the planning stage. Summary information is included as **Table 1.1**.

Table 1.1: Site Summary

Site Name	Land North of A47 Normandy Way and West of A447 Ashby Road
Location	Hinckley
NGR (approx.)	SP426958
Application Site Area (ha)	16.9 (approx.)
Development Type	Residential
Flood Zone Classification	Flood Zone 1
NPPF Vulnerability	More Vulnerable
Anticipated Development Lifetime	100+ years
Environment Agency Office	East Midlands
Lead Local Flood Authority	Leicestershire County Council
Local Planning Authority	Hinckley & Bosworth Borough Council

Sources of Data

- i. Topographical Survey by Greenhatch Group, reference 42117_T
- ii. OS Explorer Series mapping
- iii. Environment Agency (EA) consultation
- iv. EA Risk of Flooding from Surface Water Data
- v. EA 1m 2022 Light Detection and Ranging (LiDAR) Data

- vi. Hinckley and Bosworth Borough Council Level 1 Strategic Flood Risk Assessment
- vii. Hinckley and Bosworth Borough Council Level 2 Strategic Flood Risk Assessment
- viii. Leicestershire County Council Preliminary Flood Risk Assessment
- ix. Leicestershire County Council Local Flood Risk Management Strategy
- x. Humber River Basin District Flood Risk Management Plan
- xi. Hinckley and Bosworth Borough Council Draft Local Plan
- xii. Hydraulic modelling of an Unnamed Ordinary Watercourse (UOW) undertaken by BWB Consulting, reference HN2-BWB-ZZ-XX-RP-YE-0001
- xiii. Severn Trent Water Sewer Records
- xiv. British Geological Survey Drift & Geology Maps

Existing Site

- 1.3 The site is located approximately 1.9km north of Hinckley town centre and is bound to the north by agricultural land, to the northeast by Hinckley and Bosworth Community Hospital and to the east by residential development and agricultural land. Normandy Way (A47) is located adjacent to the southern boundary, whilst the UOW forms the western boundary of the site. The site's location is illustrated within **Figure 1.1**.

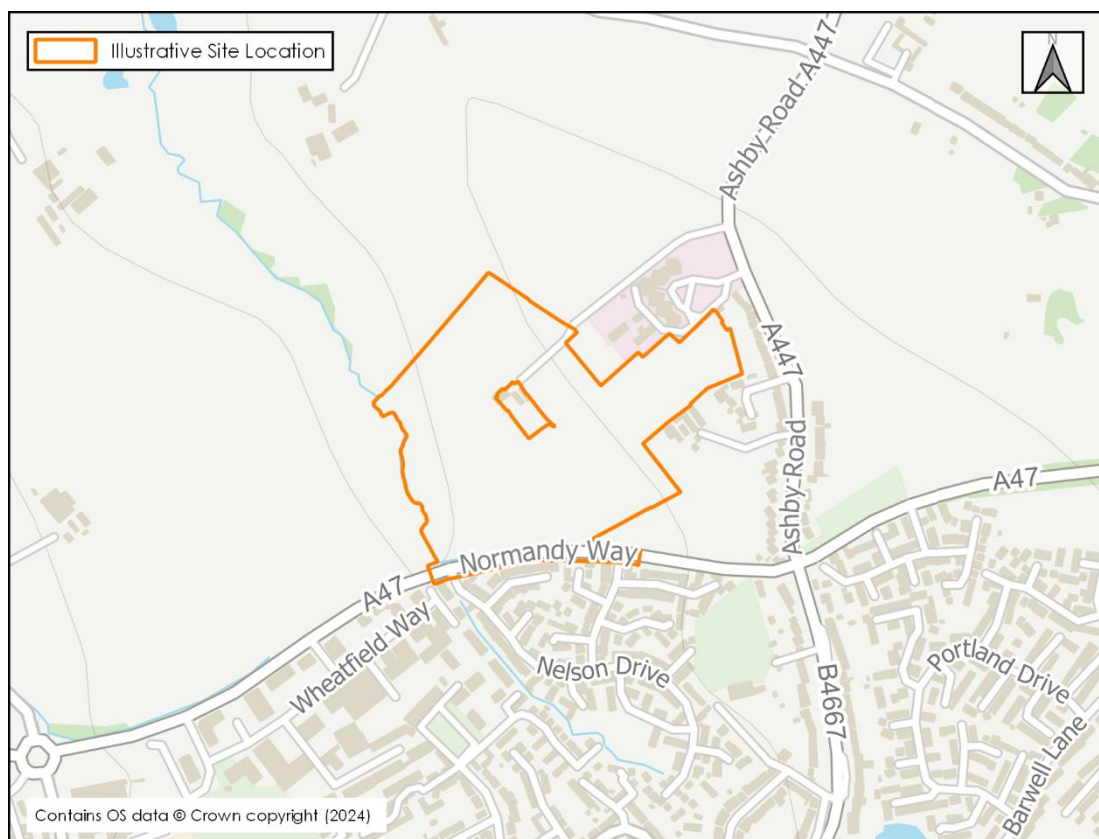


Figure 1.1: Site Location

- 1.4 A topographical survey has been undertaken and is included as **Appendix 1**. The site falls steeply in a westerly direction, towards the UOW, with levels shown to range from approximately 124.5m AOD in the east to 106.8m AOD in the west.

- 1.5 An UOW, a tributary of the River Tweed, flows along the western boundary of the site in a northerly direction. The UOW flows from within the urban development to the south of the site via twin 0.5m diameter circular culverts beneath Normandy Way where the UOW then flows as open channel. Severn Trent Water sewer records demonstrate that two surface water sewers, that drain residential areas in the upper limits of the catchment, outfall to the UOW immediately downstream of Normandy Way. The watercourse network at the site is shown in **Figure 1.2**.

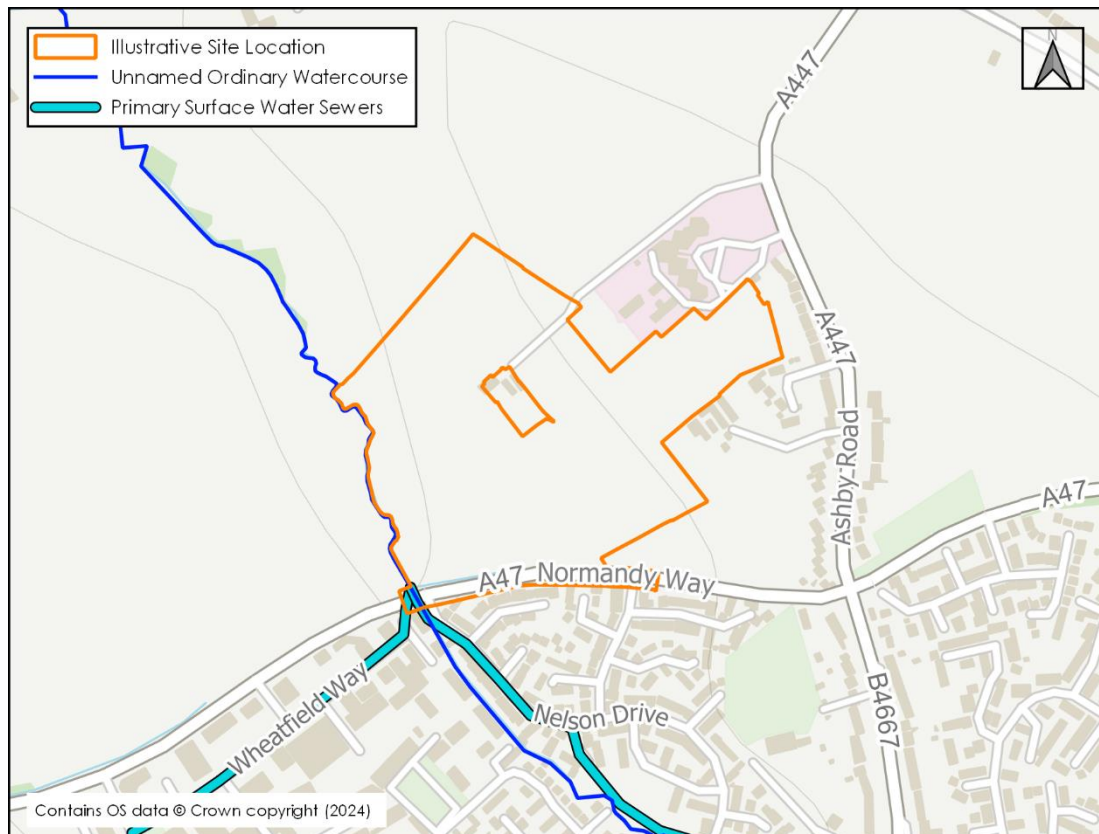


Figure 1.2: Local Watercourse Network

Proposed Development

- 1.6 The proposed development is understood to comprise an “*outline planning application with all matters reserved except for access, for the erection of up to 415 dwellings, associated open space, drainage, landscaping and infrastructure*”. It is proposed that vehicular access and egress is to be taken from Normandy Way (A47) to the south of the site. Vehicular access is proposed via the Phase 1 development located to the west of the site (reference: 22/00318/OUT).
- 1.7 Proposed plans are included as **Appendix 2**.

2. FLOOD RISK PLANNING POLICY & GUIDANCE

National Planning Policy Framework

- 2.1 The NPPF¹ sets out the Government's national policies on different aspects of land use planning in England in relation to flood risk. The PPG is also available online².
- 2.2 The PPG sets out the vulnerability to flooding of different land uses. It encourages development to be located in areas of lower flood risk where possible and stresses the importance of preventing increases in flood risk off site to the wider catchment area.
- 2.3 The PPG also states that alternative sources of flooding, other than fluvial (river flooding), should be considered when preparing a FRA.
- 2.4 The PPG includes a series of tables that define Flood Zones (Table 1), the flood risk vulnerability classification of development land uses (Table 2) and 'compatibility' of development within the defined Flood Zones (Table 3). Table 2 and Table 3 are recreated within **Appendix 3** of this report for reference.
- 2.5 This FRA is written in accordance with the NPPF and the PPG.

Flood Map for Planning

- 2.6 With particular reference to planning and development, the Flood Map for Planning identifies Flood Zones in accordance with Table 1 of the Planning Practice Guidance. Further details on the Flood Zone classifications are outlined in **Table 2.1**.

Table 2.1: Flood Zone Classifications

Flood Zone	Description
Flood Zone 1 (Low Probability)	Land having less than a 1 in 1000 annual probability of river or sea flooding (<0.1% Annual Exceedance Probability). All land outside of Flood Zone 2 and 3.
Flood Zone 2 (Medium Probability)	Land having between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% - 0.1% AEP); or between a 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5% - 0.1% AEP).
Flood Zone 3a (High Probability)	Land having a 1 in 100 or greater annual probability of river flooding (>1% AEP); or land having a 1 in 200 or greater annual probability of flooding from the sea (>0.5% AEP). This is represented by "Flood Zone 3" on the Flood Map for Planning.
Flood Zone 3b (The Functional Floodplain)	Flood Zone 3b (The Functional Floodplain) is defined as land where water must flow or be stored in times of flood. This is not identified or separately distinguished from Zone 3a on the Flood Map for Planning.

¹ Revised National Planning Policy Framework, Ministry of Housing, Communities & Local Government, amended 2023

² Planning Practice Guidance: <https://www.gov.uk/government/collections/planning-practice-guidance>

2.7 The site is shown to be located entirely within Flood Zone 1, as shown in **Figure 2.1**.

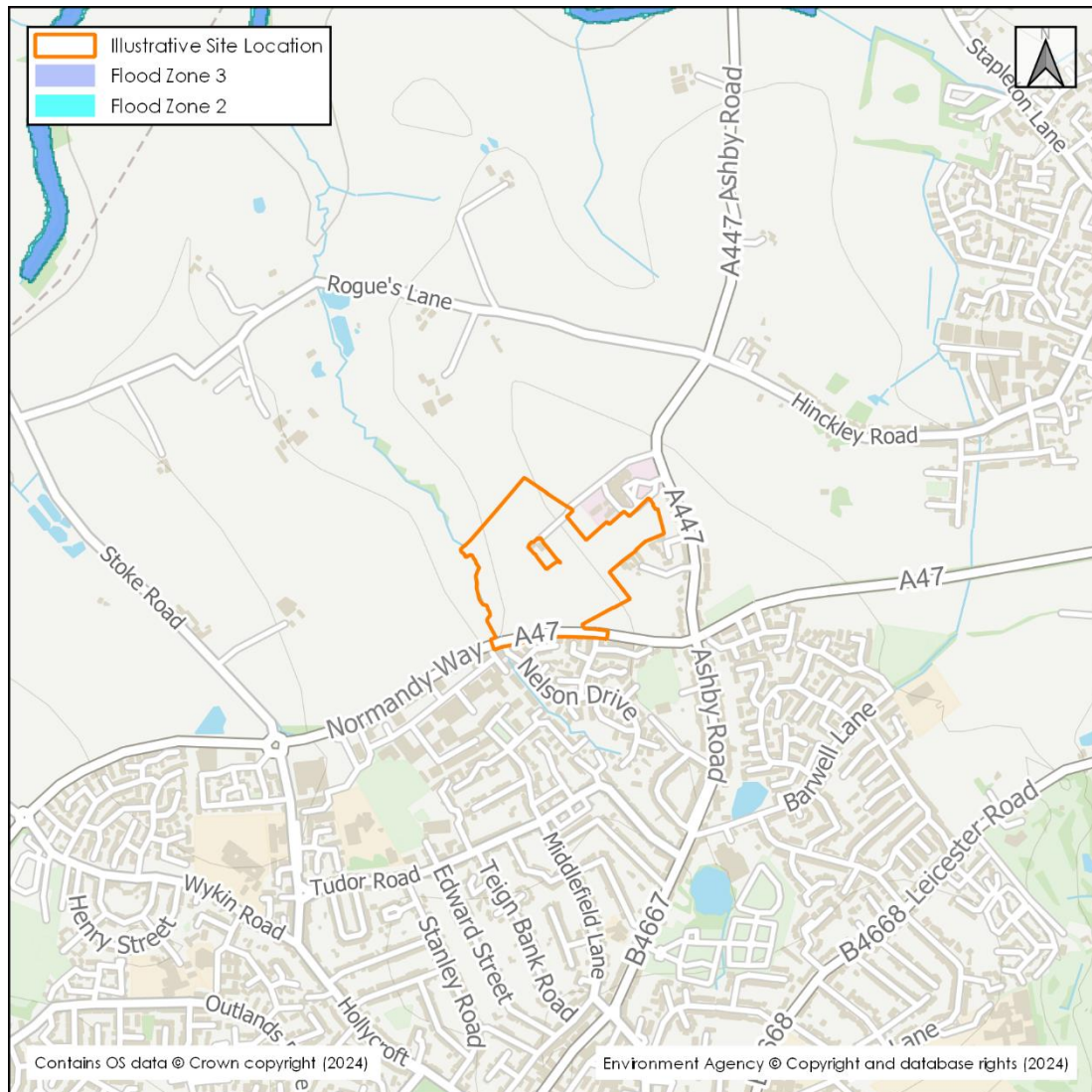


Figure 2.1: Flood Map for Planning

The Design Flood

- 2.8 The PPG identifies that new developments should be designed to provide adequate flood risk management, mitigation, and resilience against the 'design flood' for their lifetime.
- 2.9 This is a flood event of a given annual flood probability, which is generally taken as fluvial (river) and surface water (pluvial) flooding likely to occur with a 1% annual probability (a 1 in 100 chance each year), or tidal flooding with a 0.5% annual probability (1 in 200 chance each year), against which the suitability of a proposed development is assessed and mitigation measures, if any, are designed.

Climate Change

Peak River Flow

- 2.10 Predicted future changes in peak river flows caused by climate change are provided by the EA³, with a range of projections applied to regionalised 'River Basin Districts', which are further subdivided into Management Catchments.
- 2.11 The site falls within the Tame Anker and Mease Management Catchment of the Humber River Basin District. **Table 2.2** identifies the relevant peak river flow climate change allowances from this Management Catchment.

Table 2.2: Peak River Flow Climate Change Allowances for the Tame Anker and Mease Management Catchment within the Humber River Basin District

Allowance Category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2125)
Upper End	24%	30%	51%
Higher Central	15%	17%	30%
Central	10%	11%	22%

- 2.12 When determining the appropriate allowance for use in a FRA, the Flood Zone classification, flood risk vulnerability and the anticipated lifespan of the development should be considered. **Table 2.3** provides a matrix summarising the EA's guidance on determining the appropriate allowance(s).

Table 2.3: Application of Appropriate Peak River Flow Climate Change Allowances

Flood Zone	Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water Compatible
1	Use the central allowance where a location may fall within Flood Zone 2 or 3 in the future.				
2	Use the higher central allowance	Use the central allowance			
3a	Use the higher central allowance	Development should not be permitted	Use the central allowance		
3b	Use the higher central allowance	Development should not be permitted			Use the central allowance

³ Environment Agency, Flood risk assessments: climate change allowances: <https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances>. Last accessed March 2024.

Flood Zone	Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water Compatible
If development is considered appropriate by the local authority when not in accordance with Flood Zone vulnerability categories, then it would be appropriate to use the higher central allowance.					

- 2.13 The site is located entirely within Flood Zone 1; the proposed development is classified as 'More Vulnerable', and it has an anticipated lifespan of at least 100 years. Therefore, the Central allowance for the '2080s' epoch will be considered.
- 2.14 Therefore, to ensure the development is designed adequately for its lifetime, a climate change (CC) allowance of 22% will be applied to the design flood to identify minimum development levels.

Strategic Flood Risk Assessment

- 2.15 A Strategic Flood Risk Assessment (SFRA) is a study carried out by one or more local planning authorities to assess the risk to an area from flooding from all sources, now and in the future.
- 2.16 The Hinckley and Bosworth Borough Council Level 1 SFRA⁴ has been reviewed in the production of this FRA. The SFRA provides information specific to the site location in the form of fluvial, surface water and groundwater flood risk mapping, as well as records of historical flooding. It also includes flood risk policy and guidance for the area. Information from the Level 1 SFRA will be referenced within **Section 3**.
- 2.17 The Hinckley and Bosworth Borough Council Level 2 SFRA⁵ was produced to facilitate the application of Sequential and Exception Tests to screen allocated development sites. The proposed application site is not referenced within the Level 2 SFRA. Upon review, no applicable information in relation to flood risk at the site was identified.

Preliminary Flood Risk Assessment

- 2.18 A Preliminary Flood Risk Assessment (PFRA) is an assessment of floods that have taken place in the past and floods that could take place in the future. It generally considers flooding from surface water runoff, groundwater and ordinary watercourses, and is prepared by the Lead Local Flood Authorities (LLFAs).
- 2.19 The Leicestershire County Council PFRA⁶ considers flooding from surface water runoff, groundwater, ordinary watercourses and canals. However, no historical instances of flooding at the site are referenced. Information from the PFRA will be referenced within **Section 3**, where applicable.

⁴Level 1 Strategic Flood Risk Assessment (JBA Consulting, July 2019)

⁵Level 2 Strategic Flood Risk Assessment (JBA Consulting, May 2020)

⁶Preliminary Flood Risk Assessment (Leicestershire County Council, June 2011)

Local Flood Risk Management Strategy

- 2.20 A Local Flood Risk Management Strategy (LFRMS) is prepared by an LLFA to help understand and manage flood risk at a local level.
- 2.21 The LFRMS aims to ensure that the knowledge of local flood risk issues is communicated effectively so that they can be better managed. The LFRMS also aims to promote sustainable development and environmental protection.
- 2.22 The Leicestershire County Council LFRMS⁷ has been reviewed and no applicable information in relation to flood risk at the site was identified.

River Basin Flood Risk Management Plan

- 2.23 Flood Risk Management Plans (FRMPs) explain the risk of flooding from rivers, the sea, surface water, groundwater and reservoirs. FRMPs set out how risk management authorities will work with communities to manage flood and coastal risk. Risk management authorities include the Environment Agency, Natural Resources Wales, local councils, internal drainage boards, Highways England and LLFAs.
- 2.24 The first FRMPs were published in March 2016 with the next revisions published in 2022. They describe actions to manage flood risk across England between 2021 to 2027.
- 2.25 The site is located within the Humber River Basin District, and the Humber River Basin District FRMP⁸ has been reviewed. No relevant site scale objectives have been identified.

Section 19 Flood Investigation Reports

- 2.26 Under their duties of the Flood and Water Management Act 2010, LLFAs have a responsibility to publish reports of investigations of flood incidents. A Section 19 flood investigation report is a public statement of the circumstances of a historical flood event and what parties have a role in managing the risks. The investigation does not always give an in-depth analysis of the flood risk or mechanisms, but it can provide a valuable record of past events.
- 2.27 Leicestershire County Council have published 35 Section 19 reports on their website, which document the flooding that occurred between 2014 and 2022. The reports have been reviewed in relation to the site's location, but no evidence of flooding at the site or in the vicinity of the site was identified.

Local Plan

- 2.28 Hinckley and Bosworth Borough Council have produced a draft Local Plan⁹ which aims to set out the vision and objectives for the growth of the borough up to 2039.

⁷ Local Flood Risk Management Strategy (Leicestershire County Council, February 2024)

⁸ Humber River Basin District Flood Risk Management Plan (Environment Agency, December 2022)

⁹ Hinckley and Bosworth local Plan 2020-2039 (Hinckley and Bosworth Borough Council, June 2021)

2.29 The draft Local Plan includes *Policy CC02 Flood Risk*, which notes:

- Where development is permitted within flood risk areas, it must demonstrate that, where required, it will reduce fluvial and surface water flood risk and manage residual risks, address the impacts of climate change through appropriate flood mitigation and adaption measures, including enhancements to existing defences.
- All development proposals should, where possible, include measures to reduce and manage surface water through appropriate Sustainable Drainage Systems (SuDS) so as to minimise and manage flood risk and improve water quality.

2.30 It should be noted that Hinckley and Bosworth Borough Council are currently working on a new Local Plan which will set out land allocations and planning policies for the period 2020 to 2041.

2.31 The Strategic Housing and Economic Land Availability Assessment (SHELAA) Report¹⁰ provides an assessment of land within the Borough. The purpose of the document is to support the delivery of sufficient land and potential development sites in suitable locations across the borough, in line with Government objectives and policy. The site is identified across two assessment sites 'AS1029 A Land North of A47 and East of Stoke Road, Hinckley' and 'AS1031 A Westfield Farm, Ashby Road, Hinckley'. The site is referenced as being suitable, available and achievable across both parcels with an overall assessment of 'developable'.

Other Relevant Policy and Guidance

2.32 This FRA has considered the following document when assessing sources of flood risk and when recommending mitigation and resilience measures.

Flood Risk to People and New Developments

2.33 The Flood Risk to People (FD2321/TR1)¹¹ document was prepared as a research project considering flood hazard and factors that affect it.

2.34 Flood Risk Assessment Guidance for New Development (FD2320/TR2)¹² provides a framework and guidance for assessing and managing flood risks for new developments and sets flood hazard thresholds.

2.35 Hazard ratings are derived using the following equation in line with the above:

$$\text{Hazard Rating} = D * (V+0.5) + DF$$

Where:

D = depth

V = velocity

DF = debris factor

¹⁰ Strategic Housing and Economic Land Availability Assessment (SHELAA) Report (Hinckley and Bosworth Borough Council, June 2020)

¹¹ Flood Risk to People Methodology (FD2321/TR1), Defra/Environment Agency, 2006

¹² Flood Risk Assessment Guidance for New Development (FD2320/TR2), Defra/Environment Agency, 2005

- 2.36 A supplementary note¹³ provides clarification of the hazard rating thresholds which should be used for development planning and control use. **Table 2.4** identifies the thresholds of the flood hazard categories.

Table 2.4: Hazard to People¹⁴

Threshold for Flood Hazard Rating	Degree of Flood Hazard	Description
< 0.75	Low	Caution "Flood zone with shallow flowing water or deep standing water"
0.75 - 1.25	Moderate	Danger for some (i.e.: children, the elderly and the infirm) "Danger: Flood Zone with deep or fast flowing water"
1.25 - 2.0	Significant	Danger for most (includes the general public) "Danger: Flood Zone with deep fast flowing water"
2.0 >	Extreme	Danger for all (includes the emergency services) "Extreme Danger: Flood Zone with deep fast flowing water"

¹³ Supplementary Note on Flood Hazard Ratings and Thresholds for Development Planning and Control Purpose – Clarification of the Table 13.1 of FD2320/TR2 and Figure 3.2 of FD2321/TR1. (http://randd.defra.gov.uk/Document.aspx?Document=FD2321_7400_PR.pdf)

¹⁴ 2008, DEFRA. Supplementary Note on Flood Hazard Ratings and Thresholds for Development Planning and Control Purposes.

3. POTENTIAL SOURCES OF FLOOD RISK

- 3.1 Flooding can occur from a variety of sources, or combination of sources, which may be natural or artificial. **Table 3.1** below identifies the potential sources of flood risk to the site in its current condition, and the impacts which the development could have in the wider catchment, prior to mitigation. These are discussed in greater detail in the forthcoming section. The mitigation measures proposed to address flood risk issues and ensure the development is appropriate for its location are discussed within **Section 4**.

Table 3.1: Pre-Mitigation Sources of Flood Risk

Flood Source	Potential Risk				Description
	High	Medium	Low	None	
Fluvial			X		The site is located entirely within Flood Zone 1. Bespoke hydraulic modelling has shown the site to be at low risk of flooding from the adjacent UOW.
Coastal				X	The site is removed from any coastal/tidal influence.
Canals				X	There are no canals in the vicinity of the site.
Groundwater			X		The site is shown to fall within an area predicted to be at a low susceptibility to groundwater flooding.
Reservoirs and waterbodies			X		The site is shown to fall outside of the area at risk of reservoir failure.
Pluvial runoff			X		The majority of the site is at a low to very low risk of surface water flooding.
Sewers			X		There are no public sewers located within the majority of the site. A public foul rising main and two public surface water sewers are located within the south of the site, within and adjacent to Normandy Way. In the event of exceedance of surrounding sewers, flows are not expected to impact the site following bespoke hydraulic modelling.
Effect of Development			X		Development will not result in impedance/loss of fluvial or surface water flow routes.

Flood Source	Potential Risk				Description
	High	Medium	Low	None	
on Wider Catchment	X				The development will increase the area of impermeable surfaces, leading to a potential increase in runoff if left unmitigated.

Fluvial Flood Risk

- 3.2 Flooding from watercourses occurs when flows exceed the capacity of the channel, or where a restrictive structure is encountered, which leads to water overtopping the banks into the floodplain. This process can be exacerbated when debris is mobilised by high flows and accumulates at structures.
- 3.3 The site is located entirely within Flood Zone 1, which is land defined as having a low probability of flooding from rivers or sea. The nearest EA Flood Extents are located approximately 1.6km north of the site, attributed to the River Tweed.
- 3.4 An UOW is shown to flow adjacent to the western boundary of the site, and outfalls to the River Tweed approximately 2.0km downstream. The UOW is not represented on the EA's Flood Map for Planning due to its small draining catchment area (<3km²).
- 3.5 A ditch is shown to be present adjacent to the southern site boundary. The connectivity of this feature is not known; however, it is assumed to be highway drainage and therefore flows are anticipated to be low.

Historical Flooding

- 3.6 The EA Historical Flood Map shows the nearest recorded flood outline to be located approximately 6.8km west of the site attributed to the River Trent in 1992. The EA have confirmed that they do not hold any information for the site.
- 3.7 The Level 1 SFRA references no instances of fluvial flooding at the site.

Hydraulic Modelling

- 3.8 To provide a detailed understanding of fluvial flooding at the site from the UOW, BWB Consulting Ltd completed a hydraulic modelling study in April 2022. Following the release of significant updates to best-practice methodology for hydrological assessments, the model was updated with new flows in July 2023. The details of the hydraulic modelling exercise, updates and detailed flood maps are available in the Hydraulic Modelling Technical Note (**Appendix 4**).
- 3.9 The floodplain extents at the site have been summarised below and are shown in **Figure 3.1** with modelled flood levels shown in **Table 3.2**. Adjacent to the site, flows remain in channel and therefore the proposed residential development is shown to be sequentially located outside of all modelled flood extents from the UOW.

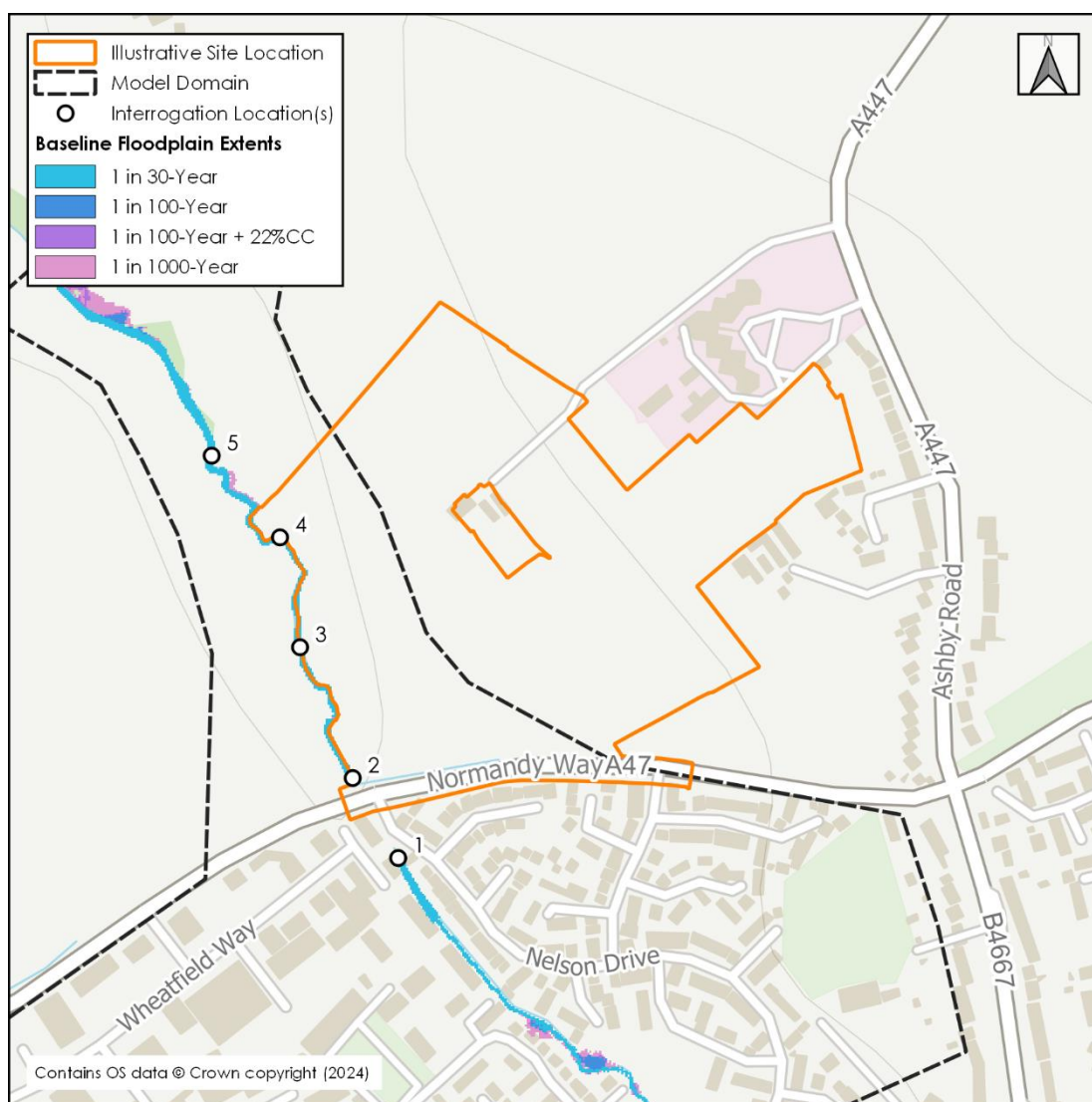


Figure 3.1: Fluvial Floodplain Extents

Table 3.2: Modelled Flood Levels (m AOD)

Interrogation Location	1 in 30-Year	1 in 100-Year	1 in 100-Year + 22%CC	1 in 1000-Year
1	109.04	109.09	109.13	109.73
2	108.11	108.22	108.29	108.47
3	107.15	107.30	107.39	107.62
4	106.71	106.84	106.92	107.11
5	106.06	106.16	106.22	106.35

3.10 Overall, the site is considered to be at a low risk of flooding from fluvial sources.

Groundwater Flood Risk

- 3.11 Groundwater flooding occurs when the water table rises above ground elevations, or it rises to depths containing basement level development. It is most likely to happen in low lying areas underlain by permeable geology. This is most common on regional scale chalk aquifers, but there may also be a risk on sandstone and limestone aquifers or on thick deposits of sands and gravels underlain by less permeable strata such as that in a river valley.
- 3.12 British Geological Survey (BGS) mapping shows the site to be underlain by Mercia Mudstone Group, which is designated by the EA as a Secondary B Aquifer. Secondary B Aquifers are defined as predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering.
- 3.13 Superficial deposits of Alluvium (Clay, Silt, Sand and Gravel), Bosworth Clay Member (Clay and Silt), Wolston Sand and Gravel (Sand and Gravel), Oadby Member (Diamicton) and Dunsmore Gravel (Sand and Gravel) are expected to be present throughout the site, as shown in **Figure 3.2**.

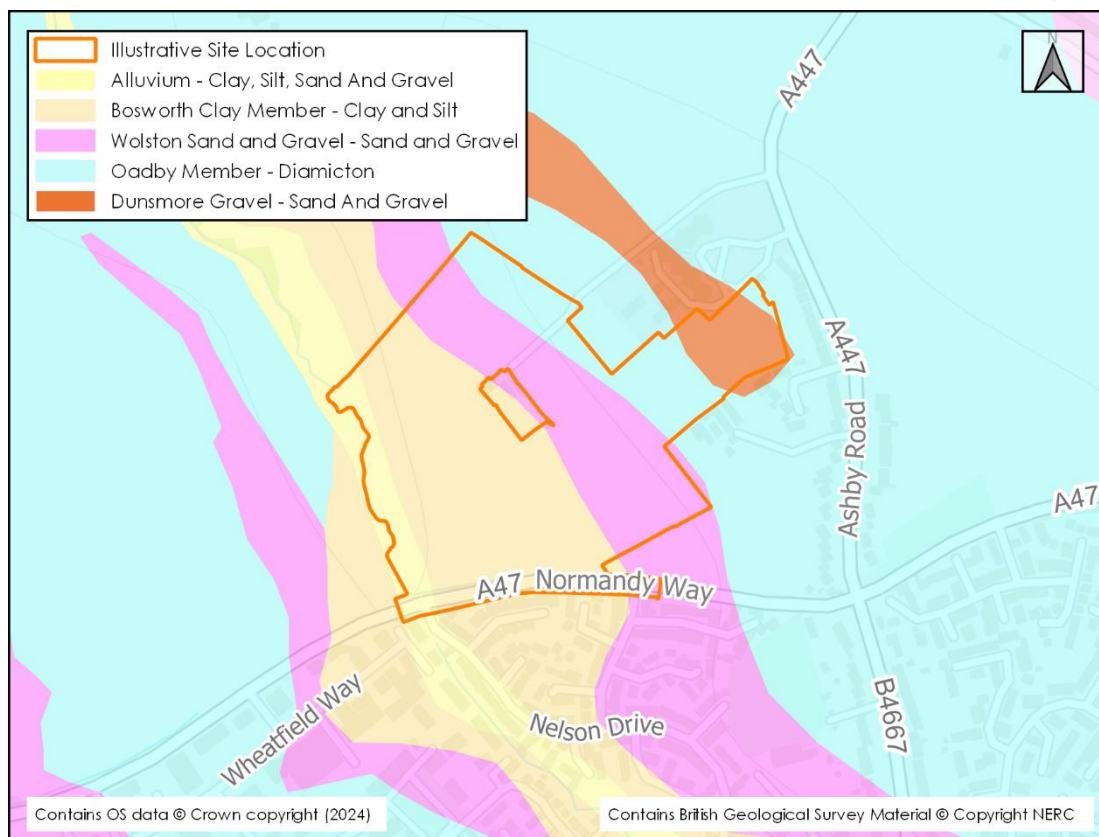


Figure 3.2: BGS Superficial Deposits

- 3.14 The superficial deposits of Alluvium, Wolston Sand and Gravel Member and Dunsmore Gravel are designated as Secondary A Aquifers. Bosworth Clay Member is designated as Unproductive Strata and Oadby Member is designated as a Secondary (Undifferentiated) Aquifer.

- Secondary A Aquifers are defined as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.
 - Secondary (Undifferentiated) Aquifers are assigned in cases where it has not been possible to attribute either category A or B to a rock type.
 - Unproductive Strata is defined as rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.
- 3.15 A historic BGS borehole log (reference: SP49NW25), located to the south west of the site, reports ground conditions to be comprised of Mercia Mudstone Group with overlying superficial deposits of Alluvium. The borehole record also notes slight water seepage at 1.5m below ground level (bgl).
- 3.16 The Hinckley and Bosworth Borough Council SFRA Groundwater Susceptibility mapping shows the site to be at a less than 25% susceptibility to groundwater flooding. It should be noted that the mapping is based on strategic scale mapping that uses a 1km² grid. It identifies areas susceptible to flooding from groundwater at a broad scale on the basis of geological and hydrogeological conditions. Therefore, the classification could potentially be based on another area within the cell.
- 3.17 The superficial deposits of Alluvium, located to the west of the site, are shown to be in continuity with the adjacent UOW and during periods of high flows in the river and heavy rainfall, groundwater levels within the west of the site may rise and pose a risk to development. However, the site is shown to slope towards the watercourse and the Alluvium deposits are confined to the western boundary of the site, therefore, the overall risk of groundwater flooding to the site is considered to be low.

Flood Risk from Reservoirs & Large Waterbodies

- 3.18 Flooding can occur from large waterbodies or reservoirs if they are impounded above the surrounding ground levels or are used to retain water in times of flood. Although unlikely, reservoirs and large waterbodies could overtop or breach leading to rapid inundation of the downstream floodplain.
- 3.19 To help identify this risk, reservoir failure flood risk mapping has been prepared by the EA; this shows the largest area that might be flooded if a reservoir were to fail and release the water it holds. The map displays a worst-case scenario and is only intended as a guide.
- 3.20 There are two flooding scenarios shown on the reservoir flood maps: a 'dry-day' and a 'wet-day'. The 'dry-day' scenario predicts the flooding that would occur if the dam or reservoir failed when rivers are at normal levels. The 'wet-day' scenario predicts how much worse the flooding might be if a river is already experiencing an extreme flood.
- 3.21 The nearest reservoir failure flood extent is located approximately 3.8km north east of the site, attributed to Mallory Park Large Lake during a 'wet-day'.
- 3.22 There are no large waterbodies upstream of, or in the vicinity of, the site.

- 3.23 Therefore, the risk of flooding from reservoirs and large waterbodies is considered to be low.

Pluvial Flood Risk

- 3.24 Pluvial flooding can occur during prolonged or intense storm events when the infiltration potential of soils, or the capacity of drainage infrastructure is overwhelmed leading to the accumulation of surface water and the generation of overland flow routes.
- 3.25 Risk of Flooding from Surface Water (RoFSW) mapping has been collated and published by the EA; this shows the potential flooding which could occur when rainwater does not drain away through the normal drainage systems or soak into the ground, but lies on or flows over the ground instead. An extract from the mapping is included as **Figure 3.3**.

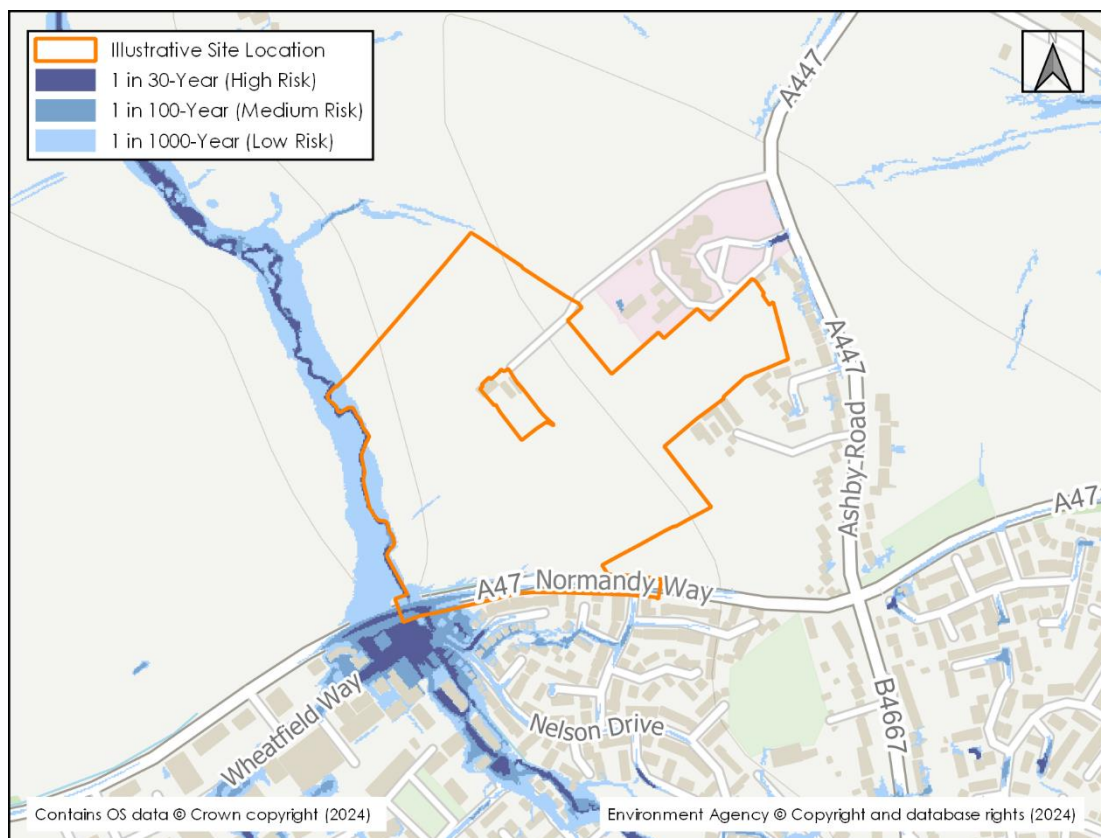


Figure 3.3: Surface Water Flood Risk Mapping

- 3.26 The majority of the site is shown to be at a very low risk of surface water flooding. A pluvial flow route, presenting a low (1 in 1000-year) to high (1 in 30-year) surface water flood risk is shown to be present along the western site boundary, associated with the UOW. Given that fluvial risk is the primary flooding mechanism from this source, the results associated with the hydraulic modelling of the UOW are thought to supersede these extents.
- 3.27 There is a small area of low surface water flood risk located within the west of the site, associated with a topographical depression, and to the south of the site, associated with the highway ditch.

- 3.28 Site access and egress via Normandy Way is shown to be at a low to medium (1 in 100-year) risk of surface water flooding. Surface water depth mapping shows depths of less than 150mm presenting a low hazard in the 1 in 100-year event. It should be noted that the culvert beneath Normandy Way is unlikely to be represented within the mapping and therefore the extents within this area are thought to be conservative.
- 3.29 Overall, the site is considered to be at a low risk of flooding from pluvial sources.

Flood Risk from Sewers

- 3.30 Sewer flooding can occur when the capacity of the infrastructure is exceeded by excessive flows, or as a result of a reduction in capacity due to collapse or blockage, or if the downstream system becomes surcharged. This can lead to the sewers flooding onto the surrounding ground via manholes and gullies, which can generate overland flows.
- 3.31 The local sewerage undertaker is Severn Trent Water. A copy of their asset plans are included as **Appendix 5**. There are no sewerage assets located within the majority of the site. A 200mm foul water rising main is shown to be located within the south of the site, adjacent to Normandy Way and two public surface water sewers (700mm and 900mm diameter) are shown to outfall to the UOW within the south west of the site.
- 3.32 The hydraulic modelling exercise includes a representation of the sewer networks upstream of the site to understand the capacity of the sewer network. The proposed development is shown to be unaffected in the event of sewer exceedance. In the event of exceedance of the assets located in Ashby Road, flows are expected to follow local topography and flow away from the site.
- 3.33 Overall, the site is considered to be at a low risk of flooding from sewers.

Effect of Development on Wider Catchment

Displacement of Floodplain

- 3.34 The proposed development will not result in the displacement of floodplain as flows are shown to remain in channel adjacent to the site.

Impedance of Flood Flows

- 3.35 The proposed development will not result in impedance or loss of overland flow routes.

Development Land Use/Drainage Considerations

- 3.36 The proposed development will increase the area of impermeable surfaces at the site. In turn, this will likely result in an increase in surface water runoff, which could increase flood risk downstream unless properly mitigated. Appropriate surface water management is discussed in **Section 4**.

4. FLOOD RISK MITIGATION

- 4.1 **Section 3** has identified the sources of flooding which could potentially pose a risk to the site and the proposed development. This section of the FRA sets out the mitigation measures which are to be incorporated within the proposed development to address and reduce the risk of flooding to within acceptable levels.

Sequential Arrangement

- 4.2 As shown in **Figure 4.1**, the proposed masterplan illustrates that all built development is removed from the modelled floodplain extents and located at least 1m above the 1 in 100-year + 22%CC design flood extent.

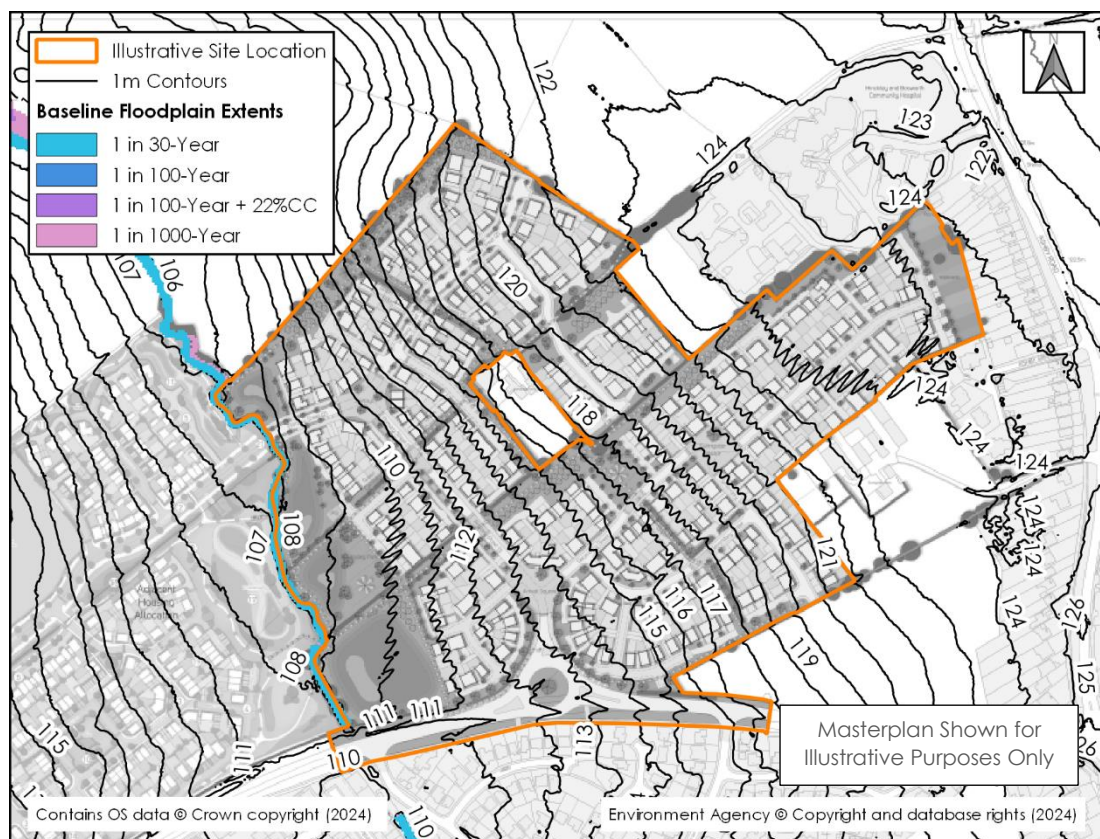


Figure 4.1: Baseline Fluvial Floodplain Extents and Contour Levels From EA LiDAR

- 4.3 The proposed residential development is therefore sequentially located outside of all modelled flood extents, including the 1 in 100-year + 22%CC extents.

Development Levels

- 4.4 The Hinckley and Bosworth Borough Council Level 1 SFRA advises that minimum finished floor levels should be set 600mm above the 1 in 100-year plus climate change (22%) peak flood level. It is therefore proposed that dwellings have finished floor levels set no lower than 600mm above the modelled 1 in 100-year +22%CC peak flood level at the nearest upstream interrogation node. This is expected to be achieved throughout the majority of the site given existing ground levels.

- 4.5 It is also recommended that finished floor levels are raised a minimum of 150mm above surrounding ground levels to help mitigate the residual risk of flooding from surface water.
- 4.6 Ground levels should be profiled to encourage pluvial runoff and overland flows away from the built development and towards the nearest drainage point.

Safe Access and Egress

- 4.7 Normandy Way is located outside of the modelled flood extents and within Flood Zone 1. Surface water depth mapping shows depths of less than 150mm presenting a low hazard in the 1 in 100-year event. Therefore, access and egress from Normandy Way can be safely achieved. It should be noted that the culvert beneath Normandy Way is unlikely to be represented within the mapping and therefore the extents within this area are thought to be conservative.
- 4.8 Vehicular access is also proposed via the Phase 1 development located to the west of the site (reference: 22/00318/OUT), on the other side of the UOW.
- 4.9 It is recommended that any proposed watercourse crossings are designed to clear span the channel with an appropriate freeboard (minimum 600mm) above the 1 in 100-year + 22%CC peak flood level to the soffit level of the structure.

Surface Water Drainage

- 4.10 To mitigate the development's impact on the current runoff regime, it is proposed to incorporate surface water attenuation and storage as part of the development proposals.
- 4.11 In brief, the development will discharge surface water at the greenfield QBAR rate. Attenuated storage will be provided with capacity for the 1 in 100-year storm including an allowance for climate change.
- 4.12 Further information on the drainage approach is provided within the accompanying Sustainable Drainage Statement, reference HN2-BWB-ZZ-XX-RP-CD-0001.

Foul Water Drainage

- 4.13 It is proposed to drain foul water from the development separately to surface water.
- 4.14 Further information on the drainage approach is provided within the accompanying Sustainable Drainage Statement, reference HN2-BWB-ZZ-XX-RP-CD-0001.

5. CONCLUSIONS AND RECOMMENDATIONS

- 5.1 This FRA has been prepared in accordance with requirements set out in the NPPF and the associated PPG. The FRA has been produced on behalf of Richborough in respect of a planning application for a proposed residential development on Land North of A47 Normandy Way and West of A447 Ashby Road, Hinckley.
- 5.2 This FRA is intended to support an outline planning application with all matters reserved except for access, for the erection of up to 415 dwellings, associated open space, drainage, landscaping and infrastructure. The level of detail included is commensurate and subject to the nature of the proposals at the planning stage.
- 5.3 This report demonstrates that the proposed development is not at significant flood risk, subject to the recommended flood mitigation strategies being implemented. The identified risks and mitigation measures are summarised within **Table 5.1**:

Table 5.1: Summary of Flood Risk Assessment

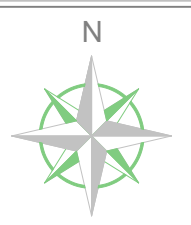
Flood Source	Risk & Proposed Mitigation Measures
Fluvial	The site is shown to be located entirely within Flood Zone 1. A hydraulic modelling exercise has been updated to assess the risk of flooding to the site from the UOW. The modelling has confirmed that the proposed development is at a low risk of flooding and is sequentially located outside of the 1 in 100-year +22%CC design event. To ensure the development is safe for its lifetime, it is recommended that finished floor levels are raised a minimum of 600mm above the nearest upstream UOW peak modelled flood level. This is expected to be achieved throughout the majority of the site given existing ground levels.
Pluvial runoff	The site is shown to be at a very low to low risk of surface water flooding. It is recommended that finished floor levels are raised a minimum of 150mm above surrounding ground levels and that ground levels are profiled to encourage overland flows away from built development.
Other Flood Risk Sources	The other flood risk sources reviewed as part of the assessment are considered to pose a low risk to the site.
Impact of the Development	The residential development has been sequentially located so as to not encroach or displace any floodplain. To mitigate the development's impact on the current runoff regime it is proposed to incorporate surface water attenuation and storage. It is proposed to drain foul water from the development separately to surface water.
This summary should be read in conjunction with BWB's full report. It reflects an assessment of the Site based on information received by BWB at the time of production.	

- 5.4 In compliance with the requirements of the NPPF, and subject to the mitigation measures proposed, the development could proceed without being subject to

significant flood risk. Moreover, the development will not increase flood risk to the wider catchment area subject to suitable management of surface water runoff discharging from the site.

APPENDICES

Appendix 1: Topographical Survey



Station	Easting (m)	Northing (m)	Level (m)
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OS Note:

This survey has been orientated to the Ordnance Survey (O.S.) National Grid OSGB36(15) via Global Navigation Satellite Systems (GNSS) and the O.S. Active Network (OS Net).

A true OSGB36 coordinate has been established near to the site centre via a transformation using the OSTN15GB & OSGM15GB transformation models.

The survey has been correlated to this point and a further one or more OSGB36 (15) points established to create a true O.S. bearing for angle orientation.

No scale factor has been applied to the survey therefore the coordinates shown are arbitrary & not true O.S. Coordinates which have a scale factor applied.
Please refer to Survey Station Table to enable establishment of the on-site grid and datum.

+ 123.66
levels shown at margins are taken from Ordnance Survey
lidar data. Access to 3rd party land unauthorised

[illegible]

Rev	Date	Description	Drawn	Q. Rev
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- Topographical Surveys
- Site Engineering
- Utility / CCTV Surveys
- Measured Building Survey
- 3D Laser Scanning
- Revit & BIM Models

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CLIENT
Richborough Estates Ltd

Hinckley North
LE10 3EA

Topographical Survey

SCALE A1@ 1: 2500	DATE Nov 2021
DRAWN ALS	QUALITY REF GH12172

Level datum	See note
Grid orientation	See note

Job number	42117
Drawing No.	42117_T
Rev.	0

Comments

This plan should only be used for its original purpose. Greenhatch Group accepts no responsibility for this plan if supplied to any party other than the original client.

All dimensions should be checked on site prior to design and construction.

Drainage information (where applicable) has been visually inspected from the surface and therefore should be treated as approximate only.

Appendix 2: Illustrative Layout

Appendix 3: NPPF Flood Risk Vulnerability and Flood Zone Compatibility

Flood Risk Vulnerability Classifications (recreated from the NPPF Planning Practise Guidance)

Vulnerability Classification	Description
Essential infrastructure	• Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk. • Essential utility infrastructure which has to be located in a flood risk area for operational reasons, including infrastructure for electricity supply including generation, storage and distribution systems; including electricity generating power stations, grid and primary substations storage; and water treatment works that need to remain operational in times of flood. • Wind turbines. • Solar farms.
Highly Vulnerable	• Police and ambulance stations; fire stations and command centres; telecommunications installations required to be operational during flooding. • Emergency dispersal points. • Basement dwellings. • Caravans, mobile homes and park homes intended for permanent residential use. • Installations requiring hazardous substances consent. (Where there is a demonstrable need to locate such installations for bulk storage of materials with port or other similar facilities, or such installations with energy infrastructure or carbon capture and storage installations, that require coastal or water-side locations, or need to be located in other high flood risk areas, in these instances the facilities should be classified as 'Essential Infrastructure'.)
More Vulnerable	• Hospitals • Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels. • Buildings used for dwelling houses, student halls of residence, drinking establishments, nightclubs and hotels. • Non-residential uses for health services, nurseries and educational establishments. • Landfill* and sites used for waste management facilities for hazardous waste. • Sites used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan.
Less Vulnerable	• Police, ambulance and fire stations which are not required to be operational during flooding. • Buildings used for shops; financial, professional and other services; restaurants, cafes and hot food takeaways; offices; general industry, storage and distribution; non-residential institutions not included in the 'more vulnerable' class; and assembly and leisure. • Land and buildings used for agriculture and forestry. • Waste treatment (except landfill* and hazardous waste facilities). • Minerals working and processing (except for sand and gravel working). • Water treatment works which do not need to remain operational during times of flood. • Sewage treatment works, if adequate measures to control pollution and manage sewage during flooding events are in place. • Car parks.
Water-Compatible Development	• Flood control infrastructure. • Water transmission infrastructure and pumping stations. • Sewage transmission infrastructure and pumping stations. • Sand and gravel working. • Docks, marinas and wharves. • Navigation facilities. • Ministry of Defence installations. • Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location. • Water-based recreation (excluding sleeping accommodation). • Lifeguard and coastguard stations. • Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms. • Essential ancillary sleeping or residential accommodation for staff required by uses in this category, subject to a specific warning and evacuation plan.

Flood Zone Compatibility (recreated from the NPPF Planning Practise Guidance)

Flood Zone	Vulnerability Classification				
	Essential infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water Compatible
Flood Zone 1 (Low Probability)	Development is appropriate	Development is appropriate	Development is appropriate	Development is appropriate	Development is appropriate
Flood Zone 2 (Medium Probability)	Development is appropriate	To be deemed appropriate an exception test is required to demonstrate: - The development will be safe for its life time without increasing flood risk elsewhere, and where possible reduce overall flood risk - the sustainability benefits of the development to the community outweigh the flood risk.	Development is appropriate	Development is appropriate	Development is appropriate
Flood Zone 3a (High Probability)	To be deemed appropriate an exception test is required to demonstrate: The development will be safe for its life time without increasing flood risk elsewhere, and where possible reduce overall flood risk the sustainability benefits of the development to the community outweigh the flood risk. Additionally, essential infrastructure should be designed and constructed to remain operational and safe in times of flood.	Development should not be permitted	To be deemed appropriate an exception test is required to demonstrate: - The development will be safe for its life time without increasing flood risk elsewhere, and where possible reduce overall flood risk - the sustainability benefits of the development to the community outweigh the flood risk.	Development is appropriate	Development is appropriate

Flood Zone	Vulnerability Classification				
	Essential infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water Compatible
Flood Zone 3b (The Functional Floodplain)	To be deemed appropriate an exception test is required to demonstrate: • The development will be safe for its life time without increasing flood risk elsewhere, and where possible reduce overall flood risk • the sustainability benefits of the development to the community outweigh the flood risk. Additionally, development should be designed and constructed to: • remain operational and safe for users in times of flood; • result in no net loss of floodplain storage; • not impede water flows and not increase flood risk elsewhere.	Development should not be permitted	Development should not be permitted	Development should not be permitted	Development is appropriate if designed and constructed to: • remain operational and safe for users in times of flood; • result in no net loss of floodplain storage; • not impede water flows and not increase flood risk elsewhere.

Appendix 4: Hydraulic Model Technical Note

ENVIRONMENT

Richborough
Land North of A47 Normandy Way
and West of A447 Ashby Road
Hinckley
Hydraulic Model Technical Note

ENVIRONMENT

Richborough
Land North of A47 Normandy Way and West of A447 Ashby
Road
Hinckley
Hydraulic Model Technical Note

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March 2024

DOCUMENT ISSUE RECORD

Document Number:	HN2-BWB-ZZ-XX-RP-YE-0001_HMTN
BWB Reference:	232746_HMTN

Rev	Date	Status	Comment	Author:	Checked:	Approved:
P01	24/08/23	S2	Draft Issue	Lucy Reeves BSc (Hons)	Max Brambani BSc (Hons) PgCert MCIWEM C.WEM	Claire Gardner BSc (Hons) MSc MCIWEM C.WEM ACMI fCMgr
P02	14/11/23	S2	Alteration to red line boundary	Lucy Reeves BSc (Hons)	Max Brambani BSc (Hons) PgCert MCIWEM C.WEM	Max Brambani BSc (Hons) PgCert MCIWEM C.WEM
P03	18/01/24	S2	Alteration to red line boundary and development description only	Sian Renwick MSci (Hons)	Lucy Reeves BSc (Hons)	Rachel Meredith BSc (Hons) MCIWEM
P04	07/03/24	S2	Alteration to red line boundary only	Sian Renwick MSci (Hons)	Lucy Reeves BSc (Hons)	Rachel Meredith BSc (Hons) MCIWEM

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- (i) The date on which this assessment was undertaken, and
- (ii) The date on which the final report is delivered

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All Environment Agency mapping data used under special license. Data is current as of March 2024 and is subject to change.

The information presented, and conclusions drawn, are based on statistical data and are for guidance purposes only. The study provides no guarantee against flooding of the study site or elsewhere, nor of the absolute accuracy of water levels, flow rates and associated probabilities.

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Appendix 1: Hydraulic Model Report

Appendix 2: Detailed Pooling Group Information

Appendix 3: Baseline Floodplain Maps

GLOSSARY & NOTATION

1D – one-dimensional hydraulic model, good for representing the hydraulics of a definitive channel or flow pathway and hydraulic structure.

2D – two-dimensional hydraulic model, good for representing complex flow routing present within the floodplain.

Annual Exceedance Probability (AEP) - the probability (%) of a flood event occurring in any year.

Catchment - the land area that drains (normally naturally) to a given point on a river, drainage system or body of water.

Design flood event - magnitude of the flood adopted for the design of the whole or part of a development, usually defined in relation to the severity of the flood in terms of its return period. Typically, the 1 in 100-year return period event including an allowance for future climate change for fluvial flood events.

DTM – Digital Terrain Model

EA – Environment Agency

ESTRY - a 1D hydraulic modelling software package published by BMT.

Flood Estimation Handbook (FEH) – industry standard guidance on rainfall and river flood frequency estimation across the UK.

Floodplain - any area of land over which water flows or is stored during a flood event.

FRA – Flood Risk Assessment

Freeboard - the height of the top of a bank, floodwall or other flood defence structure, above the design water level. Freeboard can be seen as a safety margin that makes allowance for uncertainty associated with the potentially damaging effects of flood rise or wave action.

Hydraulic Model - a mathematical (generally computer based) model of a water/sewer/storm system which is used to analyse the system's hydraulic behaviour.

LiDAR – Light Detection and Ranging aerial survey data

M AOD – metres above Ordnance Datum

Main River - a statutory type of watercourse in England and Wales, usually larger streams and rivers. The EA can carry out maintenance, improvement or construction work on main rivers to manage flood risk as part of its duties and powers.

NRFA – National River Flow Archive

OS – Ordnance Survey

Preliminary Flood Risk Assessment (PFRA) - an assessment of floods that have taken place in the past and floods that could take place in the future. It generally considers flooding from surface water runoff, groundwater and ordinary watercourses, and is prepared by the Lead Local Flood Authority.

ReFH – Revitalised Flood Hydrograph rainfall-runoff hydrological model

Return period - a statistical term defining the probability of occurrence of a flood event. Thus a 1 in 50-year flood is one likely to be equalled or exceeded on average only once in a 50-year period: a flood with a 2.0% annual probability exceedance (AEP).

Strategic Flood Risk Assessment (SFRA) - a study carried out by one or more local planning authorities to assess the risk to an area from flooding from all sources, now and in the future.

TUFLOW – a 2D fixed grid hydraulic modelling software package published by BMT.

UOW – Unnamed Ordinary Watercourse

Watercourse – a natural or man-made open channel for the conveyance of water.

Z-Shape – a layer in TUFLOW which can be used to manipulate the 2D model geometry.

1. INTRODUCTION

- 1.1 BWB Consulting Ltd has been commissioned by Richborough (the Client) to undertake updates to a hydraulic model of an Unnamed Ordinary Watercourse (UOW). The purpose of the updates is to ensure that the modelled flows are in accordance with current best practice methods.
- 1.2 The hydraulic model updates are intended to support a planning application for a proposed residential development on Land North of A47 Normandy Way and West of A447 Ashby Road, Hinckley (NGR: SP426958).

Site History

- 1.3 Hydraulic modelling of the UOW was previously undertaken by BWB Consulting in 2022 to support an adjacent planning application (reference: 22/00318/OUT) located to the west of the site, on the left bank of the UOW. The watercourse divides the Phase 1 and Phase 2 sites.
- 1.4 A planning application is now to be submitted for the Phase 2 development on the right bank of the UOW and the hydraulic model needs to be updated to account for changes in hydrology guidance and the definition of functional floodplain which have been released since the modelling was initially undertaken.

Aims and Objectives

- 1.5 To update the hydraulic model, the following objectives have been identified:
- i. Undertake a review of the hydrology assessment previously completed.
 - ii. Undertake an updated hydrological assessment of the UOW using latest methodologies.
 - iii. Update the inflows into the model following the hydrological review.
 - iv. Update the 2D hydraulic model domain with up-to-date topographical information, where available.
 - v. Undertake simulations of key flood return period events to understand the floodplain extents and peak flood levels within and adjacent to the site.
 - vi. Undertake simulations to account for climate change flows within the model.

Approach

- 1.6 To achieve the objectives identified above, the existing 1D/2D ESTRY- TUFLOW model was simulated with the updated hydrology.
- 1.7 The model has been simulated for a series of design storm events. These modelled events include the 1 in 30-year, 1 in 100-year and 1 in 1000-year events that are typically equivalent to Flood Zones 3b (Functional Floodplain), 3a and 2 respectively, used by the EA for planning purposes.

Site Description

- 1.8 The site is located approximately 1.9km north of Hinckley town centre and is bound to the north by agricultural land and Hinckley and Bosworth Community Hospital, to the east by residential development and agricultural land, to the south by Normandy Way (A47) and to the west by the UOW. The site location is shown in **Figure 1.1**.

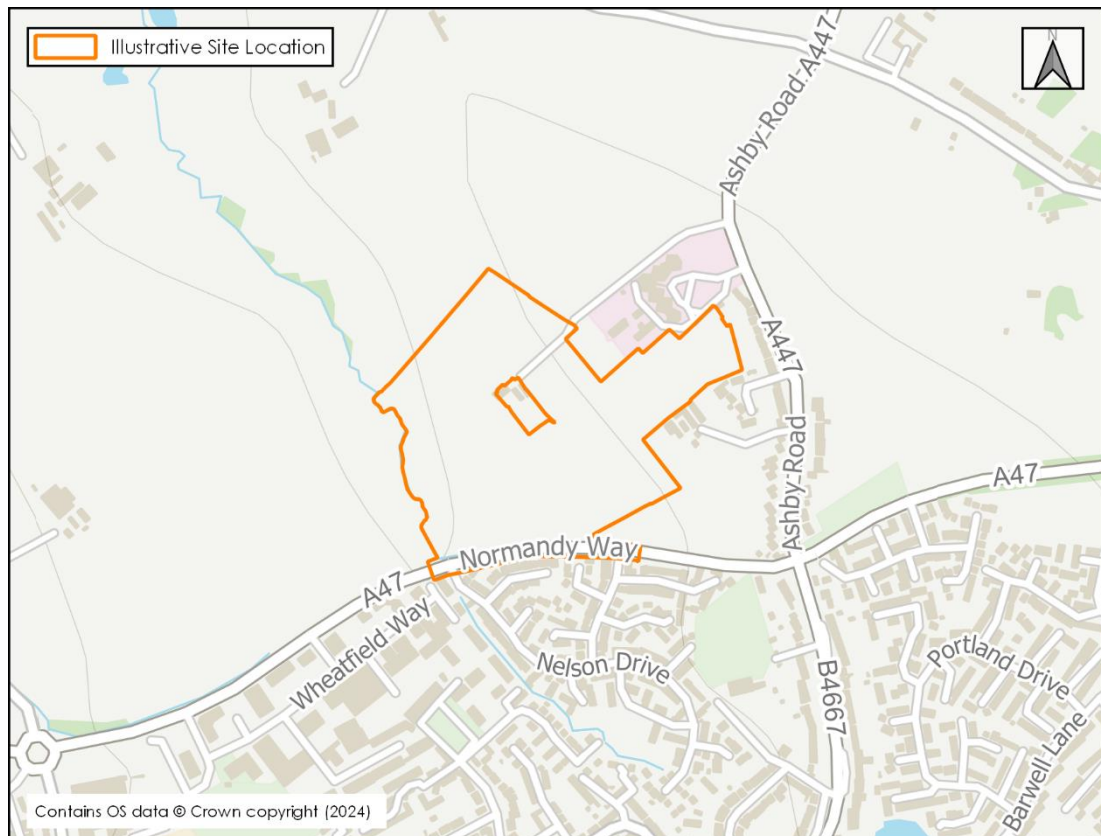


Figure 1.1: Site Location

- 1.9 An UOW, a tributary of the River Tweed, flows along the western boundary of the site in a northerly direction. The UOW flows from within the existing urban development to the south of the site via twin 0.5m diameter circular culverts beneath Normandy Way, where the UOW then flows as open channel. Severn Trent Water sewer records demonstrate that two surface water sewers, that drain residential areas in the upper limits of the catchment, outfall to the UOW immediately downstream of Normandy Way. The watercourse network at the site is shown in **Figure 1.2**.

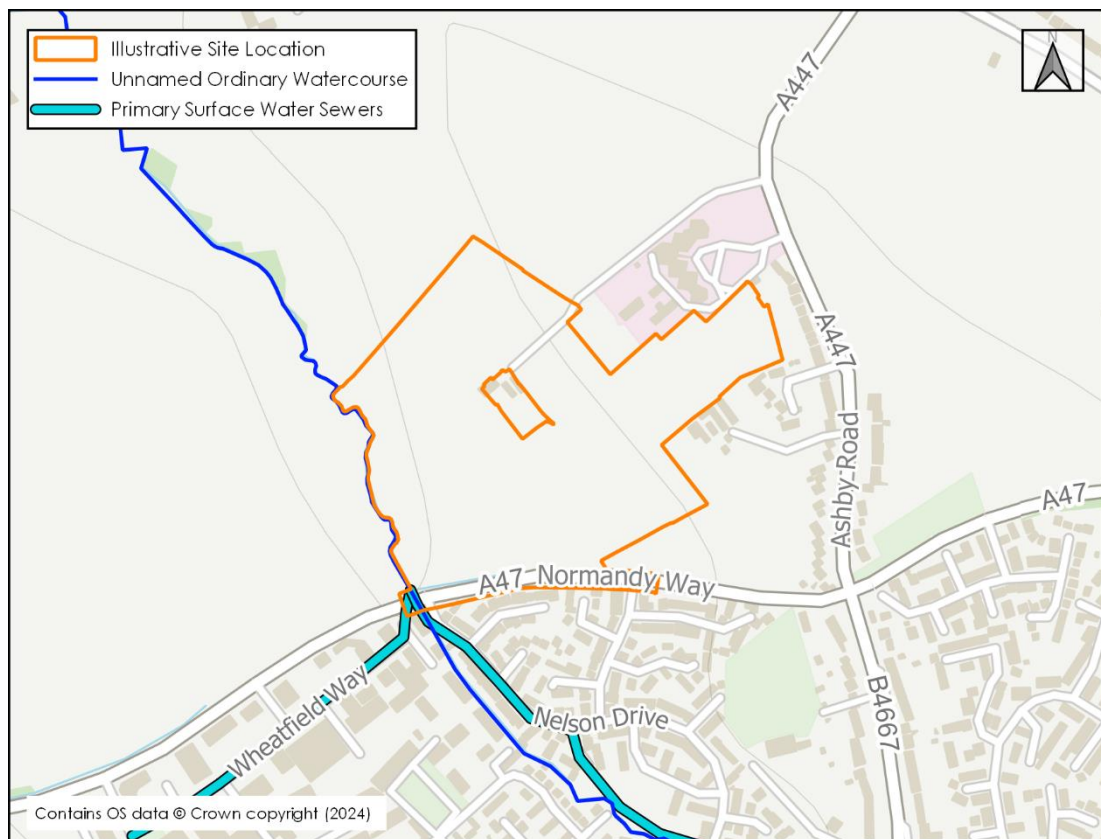


Figure 1.2: Local Watercourse Network

Previous Studies & Available Data

Hydraulic Models

- 1.10 In 2022, BWB Consulting constructed a 1D/2D ESTRY-TUFLOW model of the UOW, based on a watercourse survey completed in February 2022.
- 1.11 The final choice of peak flows for input into the model was the FEH Statistical Method with ReFH2 used to provide a hydrograph shape, scaled to the Statistical peak.
- 1.12 The 1D domain for the UOW was modelled from upstream of the site, to the rear of the dwellings located along Nelson Drive to the south of the site. The majority of the channel was represented within the 1D domain; however, the first 400mm of the watercourse, at the upstream limit of the model, was modelled in the 2D domain.
- 1.13 Due to the surface water sewers discharging into the UOW, the trunk sewers were incorporated into the model.
- 1.14 Further information on the hydraulic modelling approach can be found within the Hydraulic Modelling Report (reference: HIN-BWB-ZZ-XX-RP-YE-0002) included as **Appendix 1**.

Historical Flooding

- 1.15 EA historical flood outlines show that there are no historical flood outlines recorded at the site. However, it is possible that flooding may have taken place that has not been recorded by the EA.
- 1.16 A flood history review for the catchment has been undertaken using EA recorded flood outlines, Hinckley and Bosworth Borough Council Level 1 SFRA¹, Hinckley and Bosworth Borough Council Level 2 SFRA², Leicestershire County Council PFRA³, Leicestershire County Council Local Flood Risk Management Strategy (LFRMS)⁴, the British Chronology of Hydrological Events and online newspaper records.
- 1.17 The Level 1 SFRA notes that a surface water overland flow route exists along Stoke Road and is associated with an unnamed drain adjacent to this road; however, there are no historic flooding incidents recorded. It is not thought that this surface water flow route affects the development site.

EA Maps

- 1.18 The EA Flood Map for Planning shows the site to be located entirely within Flood Zone 1. This is likely due to the small catchment associated with the UOW meaning it was not included in the national scale mapping. The nearest Flood Zone extents are located approximately 1.6km north of the site.
- 1.19 The EA Risk of Flooding from Surface Water (RoFSW) mapping provides an indication of the floodplain associated with ordinary watercourses that are not included within the Flood Map for Planning. The mapping is included within **Figure 1.3**.
- 1.20 The mapping shows a pluvial flow route, associated with the UOW, to be present adjacent to the western site boundary. Due to the topography of the site, the extents are shown to encroach the site boundary only marginally.

¹ Level 1 Strategic Flood Risk Assessment (JBA Consulting, July 2019)

² Level 2 Strategic Flood Risk Assessment (JBA Consulting, May 2020)

³ Preliminary Flood Risk Assessment (Leicestershire County Council, June 2011)

⁴ Local Flood Risk Management Strategy (Leicestershire County Council, February 2024)

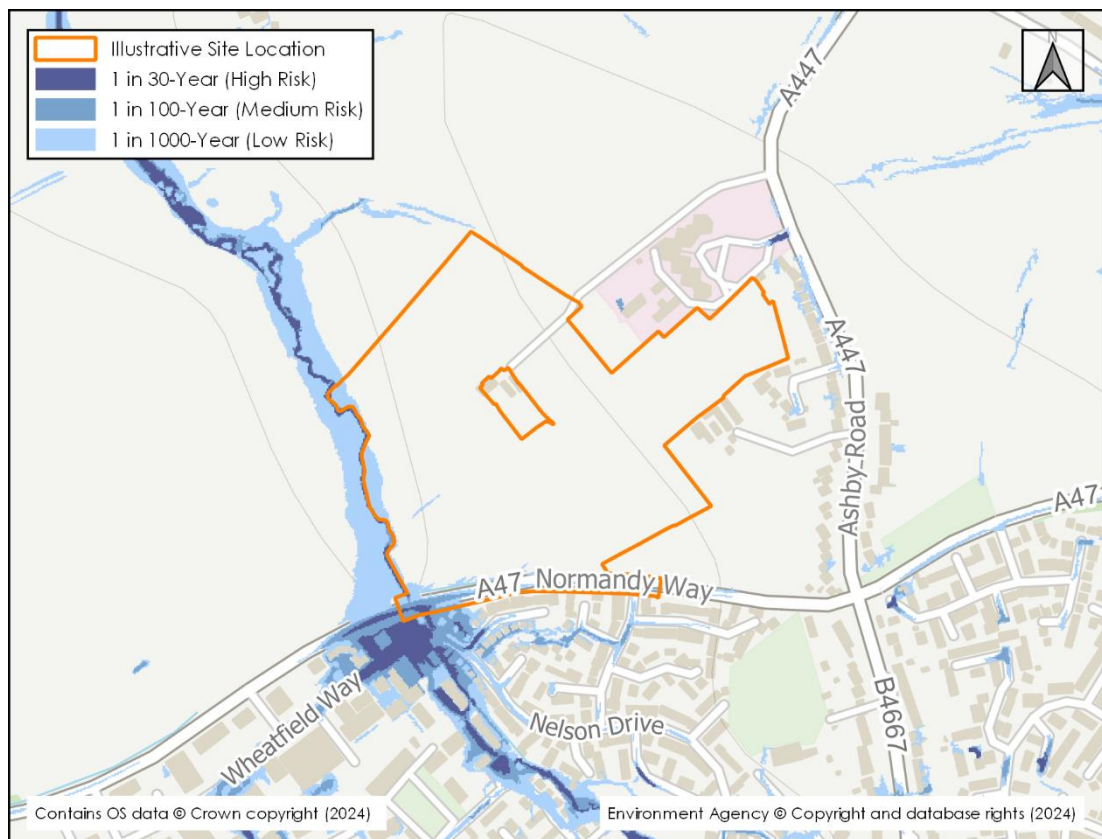


Figure 1.3: EA Risk of Flooding from Surface Water Mapping

Other Sources of Data

1.21 The BWB hydraulic model was updated using the following additional datasets as part of this exercise:

- EA LiDAR data (2022) 1m resolution composite Digital Terrain Model (DTM).
- An updated hydrological assessment of Flood Flows undertaken by BWB Consulting (**Section 2**).

Assumptions and Limitations

1.22 Several assumptions were made during the study which may lead to implications on the modelled results. However, the study has been based on the data available at the time of writing. The key assumptions and limitations are as follows:

- Any assumptions and limitations inherited from the previous hydraulic model will be carried forward into this study.
- The catchment boundary amended as part of the previous assessment is representative of the catchment.
- The URBAN50k method used to calculate URBEXT₂₀₀₀ for the revised catchment boundary has been retained as no significant changes to urban area have been identified.

- The modelling exercise has made use of the available data at the time of construction and simulation. The model represents the floodplain and channel conditions at the time of survey.
- The modelling exercise has been undertaken to produce a good representation of flood risk mechanisms in and around the study site. It has not been designed to accurately map flooding in the wider catchment.

2. HYDROLOGY

- 2.1 There have been changes in guidance relating to the calculation of flood flows since the hydraulic model was initially undertaken in 2022. The hydrology was updated in August 2023 to ensure that the modelled flows are in accordance with current best practice, using industry standard methodologies and guidance, as detailed below.

Method Statement

- 2.2 The National River Flow Archive (NRFA) Peak Flow Dataset Version 11.1 (released March 2023) will be utilised in this assessment for the purposes of identifying any potential donor stations and for the development of pooling groups.
- 2.3 Flows will be estimated using both Statistical and ReFH2 methods. Both methods are suitable for the catchment and using both will enable comparison before choosing the final method.
- 2.4 The flow estimation location, taken at the downstream extent of the hydraulic model, was retained. The catchment boundary was also reviewed, and the adjustments made as part of the previous assessment were retained.
- 2.5 Catchment descriptors remained as per the previous assessment and URBEXT was not updated as there has been no significant urban development in this area since the previous assessment.

Statistical Method

- 2.6 WINFAP (v4) was utilised to undertake a statistical analysis of the catchment using a hydrometric record of gauged catchments with similar characteristics.

QMED Development

- 2.7 Catchment descriptors were originally used to estimate the rural QMED of the study site using the revised equation from Science Report (SC050050). The FEH states that flood frequency is best estimated by gauged data and estimation of key variables from catchment descriptors alone should be a method of last resort. As such, a search was undertaken to identify any potential donor sites that could be used to adjust QMED.
- 2.8 Phase 2 of Science Report SC090031⁵ recommends using a single donor, chosen on the basis of proximity, to adjust QMED for 'small catchments' (defined as catchments with an area of less than 25km²). This method can also be applied to catchments less than 40km² and is implemented in WINFAP5.

⁵ Science Report SC090031/R0: Estimating flood peaks and hydrographs for small catchments (Phase 2), Environment Agency (2019).

- 2.9 With the guidance in mind, a search was undertaken within WINFAP to identify the closest station to the flow estimation point(s). The data quality of potential donor(s) was also reviewed.
- 2.10 Whilst the FEH recommends avoiding urbanised donors, the Littlethorpe gauge (NRFA reference: 28082) is approximately 12km from the site and only just over the 0.03 threshold for URBEXT₂₀₀₀. WINFAP allows the use of urban donors, applying the urban adjustment factor in reverse to attempt to remove the urban influence. As such, the search for donors was also extended to donors with URBEXT > 0.046 to allow WINFAP to include Littlethorpe as a donor.
- 2.11 Following a review of the Littlethorpe gauge against the nearest suitable rural donor (NRFA reference: 54102), it was decided to use the rural donor as this provided the most conservative estimate of QMED.
- 2.12 Details for the donor station used to adjust QMED, and the flow estimation point it has been applied to, are provided in **Table 2.1**. Details of the donor adjustment and final QMED estimation are provided in **Table 2.2**.

Table 2.1: Donor Station Details

Station Number	QMED from 'as rural' Observed Data (A)* (m ³ /s)	'As rural' QMED from Catchment Descriptors (B)** (m ³ /s)	Adjustment Ratio (A/B)	Flow estimation point(s) donor is applied to
54102	13.52	13.27	1.02	UOW001

Table 2.2: Overview of Estimation of QMED at each Subject Site

Site Code	Method	Initial Estimate of QMED (m ³ /s) (Rural)	Data Transfer				Final estimate of QMED (m ³ /s) (URBAN)
			Donor site NRFA no	Distance between centroids d _j (km)	Power term, a	Moderated QMED adjustment factor (A/B) ^a	
UOW001	Donor transfer	0.4	54102	25.71	0.275	1.01	0.58
Are the values of QMED consistent, for example at successive points along the watercourse and at confluences?				QMED is consistent with the size and characteristics of the catchment.			
Which version of the urban adjustment was used for QMED?				Urban adjustment was applied using Kjeldsen (2010), as applied in WINFAP.			

Derivation of Pooling Groups

- 2.13 A pooled group of hydrologically similar gauged sites was generated by the WINFAP software for the subject sites using the 'OK for Pooling' dataset. WINFAP uses the deurbanised pooling group L-moments as default.
- 2.14 The 'small catchment' pooling procedure implemented within WINFAP has been used. This procedure selects the pooling group using a similarity measure that only considered AREA and SAAR, as recommended by SC090031.

Pooling Group Review

- 2.15 The pooling group was reviewed to identify sites which may be inappropriate due to being significantly hydrologically dissimilar to the study site, or if they have any inaccuracies, uncertainties, or limitations in their data record.

Highly Permeable Stations

- 2.16 There are only a small number of small, gauged catchments within the peak flow dataset, and a number of these are located on highly permeable catchments.
- 2.17 The EA FEH guidelines do not provide explicit guidance on what to do with highly permeable stations in a pooling group when the subject site is not classed as highly permeable. However, it does set out a couple of options.
- i. Retain the permeable stations within the pooling group and adjust for non-flood years (previously known as 'permeable adjustment'). However, limitations with this approach include:
 - a. It only applied the Generalised Logistic (GL) distribution
 - b. It does not offer Enhanced Single Site analysis
 - c. It cannot be applied in WINFAP
 - ii. Remove highly permeable stations from the pooling group. The disadvantage of this approach is that any replacement stations will be less similar to the subject site in terms of AREA and SAAR, than those removed. However, EA guidelines suggest an alternative which is the acceptance of a group smaller than the default size of 500-year. This is based on SC050050 which showed the uncertainty associated with pooling does not increase much until the number of years drops below 300.
- 2.18 Given the various uncertainties and limitations around the different approaches, both will be applied for this study and the results compared before deciding on the final method.

Urban Adjustment

- 2.19 Growth curves were also adjusted for to reflect the urban influence, using the methods adopted in WINFAP⁶ which is based on those published by Kjeldsen 2010⁷.

Choice of Distribution

- 2.20 In accordance with the EA FEH Guidelines, the distribution has been chosen based on which gives the best fit from Generalised Logistic (GL), Generalised Extreme Value (GEV) and Kappa 3.
- 2.21 The only exception to this is when a pooling group has been adjusted for non-flood years as the procedure for the adjustment uses the GL distribution.
- 2.22 GL provided the best fit for both approaches.

Growth Curve Comparison

- 2.23 Further detail on pooling group composition is provided in **Appendix 2**.

Table 2.3: Derivation of Pooling Groups: UOW001_PG

Name of group	Subject site treated as gauged? (enhanced single site analysis)	Distribution used	Change made to default pooling group with reasons, including any sites investigated but retained in the group	Weighted average L-moments L-CV and L-skew (before any urban and non-flood year adjustment)
Adjusted for non-flood years	No	GL	Stations Removed: 26014 and 44008 – non-flood years over 15% of record and a review of the stations on the NRFA suggests catchment response differs to that of the site. Stations Added: None Comments: Station 36010 was reviewed for suitability as it was identified as having non-flood years over 15% of record. The catchment response was not considered to be significantly different to the study catchment and	L-CV: 0.274 L-Skew: 0.266

⁶ Wallingford HydroSolutions (2016), WINFAP 4 Urban adjustment procedures, Wallingford HydroSolutions Ltd 2016.

⁷ Kjeldsen, T.K., 2010. Modelling the impact of urbanization on flood frequency relationships in the UK. Hydrology Research, volume 41, issue 5, pp391-405

Name of group	Subject site treated as gauged? (enhanced single site analysis)	Distribution used	Change made to default pooling group with reasons, including any sites investigated but retained in the group	Weighted average L-moments L-CV and L-skew (before any urban and non-flood year adjustment)
			therefore the station was retained. Station 49005 was investigated for high discordancy; however, the station was not removed as no obvious reason for the high discordancy was found. Station 7011 was investigated due to a steep growth curve; however, the station was not removed as there is no obvious reason for the steep growth curve. The pooling group is heterogeneous; however, it is not considered possible to improve the pooling group any further.	
Highly permeable stations removed	No	GL	Stations Removed: 27073, 26016, 26014, 44008 and 7011 – BFIHOST > 0.66 Stations Added: None Comments: The pooling group is possibly heterogeneous and a review of the pooling group is optional.	L-CV: 0.255 L-Skew: 0.272

2.24 A comparison of the growth curves for the different methods is provided in **Figure 2.1**.

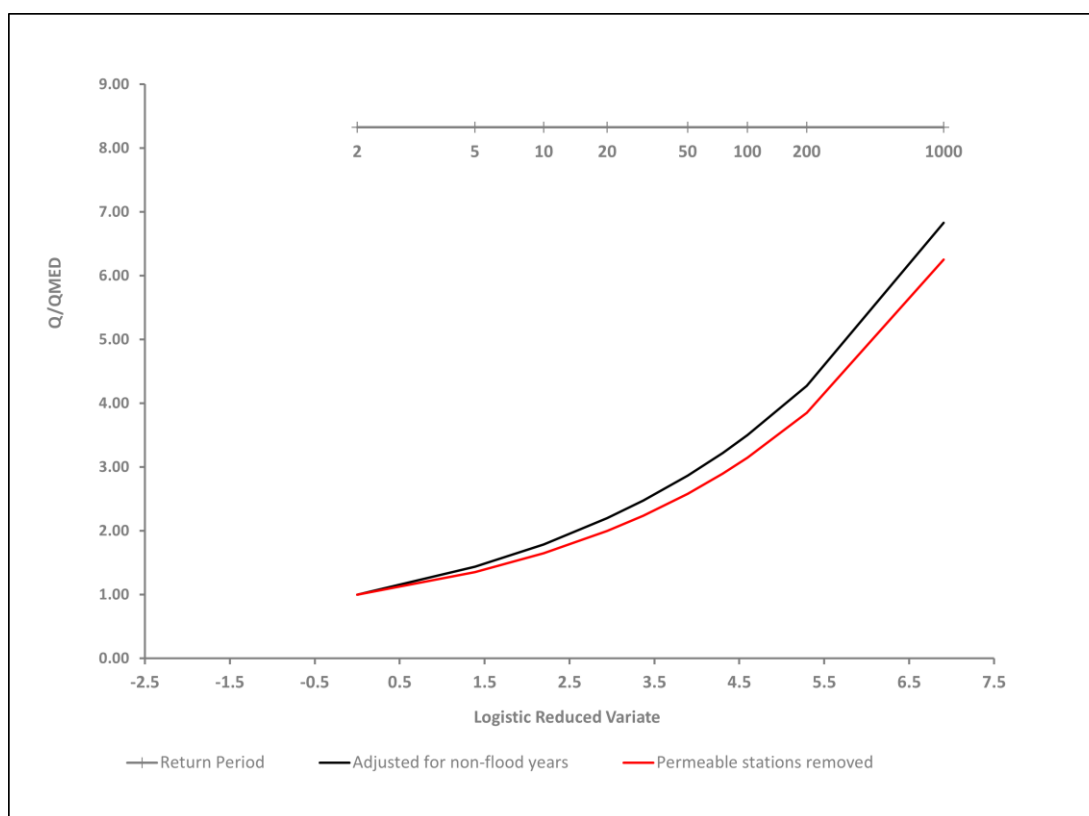


Figure 2.1: Comparison of Pooled Growth Curves

- 2.25 The growth curves are similar at the lower return periods. At around the 10-year event, the growth curve for the pooling group which has been 'adjusted for non-flood years' shows a steepening in comparison to the 'permeable stations removed' pooling group. The 'adjusted for non-flood years' pooling group provides higher flows when compared to the pooling group with 'permeable stations removed', particularly during the higher return periods.
- 2.26 The final choice of growth curve has been based on the 'adjusted for non-flood years' pooling group as this provides the highest peak flows.

Table 2.4: Final Choice of Flood Growth Curves at Subject Site

Site code	Method (SS, P, ESS)	Name of pooling group	Distribution used and reason for choice	Urban adjustment and/or non-flood years adjustment applied?	Growth factor for 1% AEP event
UOW001	P	Adjusted for non-flood years	GL distribution was chosen because it is the default distribution used for the adjustment for non-flood years.	Urban adjustment and adjustment for non-flood years applied	3.50

Table 2.5: Flood Estimates from the Statistical Method

Site Code	Flood peak (m ³ /s) for the following return periods									
	2	5	10	20	30	50	75	100	200	1000
UOW001	0.6	0.8	1.0	1.3	1.4	1.7	1.9	2.0	2.5	3.9

Revitalised Flood Hydrograph (ReFH) Method

- 2.27 The ReFH2 Revitalised Flood Hydrograph Modelling Tool (Version 3.2) was used to undertake an estimation of the peak flows for the subject sites.

Table 2.6: Overview of Parameters for ReFH2 Method

Site code	Method OPT: Optimisation BR: Baseflow recession fitting CD: Catchment descriptors DT: Data transfer	Tp (hours) Time to peak	C _{max} (mm) Maximum storage capacity	BL (hours) Baseflow lag	BR Baseflow recharge
All	Parameters calculated using catchment descriptors				
Description of flood event analysis carried out			Flood event analysis is not possible as catchment is ungauged.		

Table 2.7: Design Events

Site code	Rainfall DDF model	Season of design event	Storm duration	Selected interval	Initial soil moisture (Cini)	Initial baseflow (BFO)
UOW001	FEH13	Winter	5.5hr	0.5hr	Default value	Default value
Comments	A uniform 5.5hr winter storm will be applied at the modelling stage.					

Table 2.8: Flood Estimates from the ReFH Method

Site Code	Flood peak (m ³ /s) for the following return periods									
	2	5	10	20	30	50	75	100	200	1000
UOW001	0.8	1.0	1.2	1.5	1.6	1.8	2.0	2.2	2.6	3.9

Discussion and Summary of Results

- 2.28 A comparison of the peak flow results for the different estimation methods for the 1 in 2-year and 1 in 100-year events is provided in **Table 2.9**. Comparisons of the growth curves for both methods are shown in **Figure 2.2**.
- 2.29 The Statistical method provides a steeper growth curve when compared to the ReFH2 method. The ReFH2 method provides greater flows for the majority of the return periods and the Statistical provides greater flows for events greater than the 200-year event.

Table 2.9: Comparison of Results

Site code	1 in 2-year peak flows			1 in 100-year peak flows		
	Statistical	ReFH	Ratio	Statistical	ReFH	Ratio
UOW001	0.6	0.8	0.8	2.0	2.2	0.9

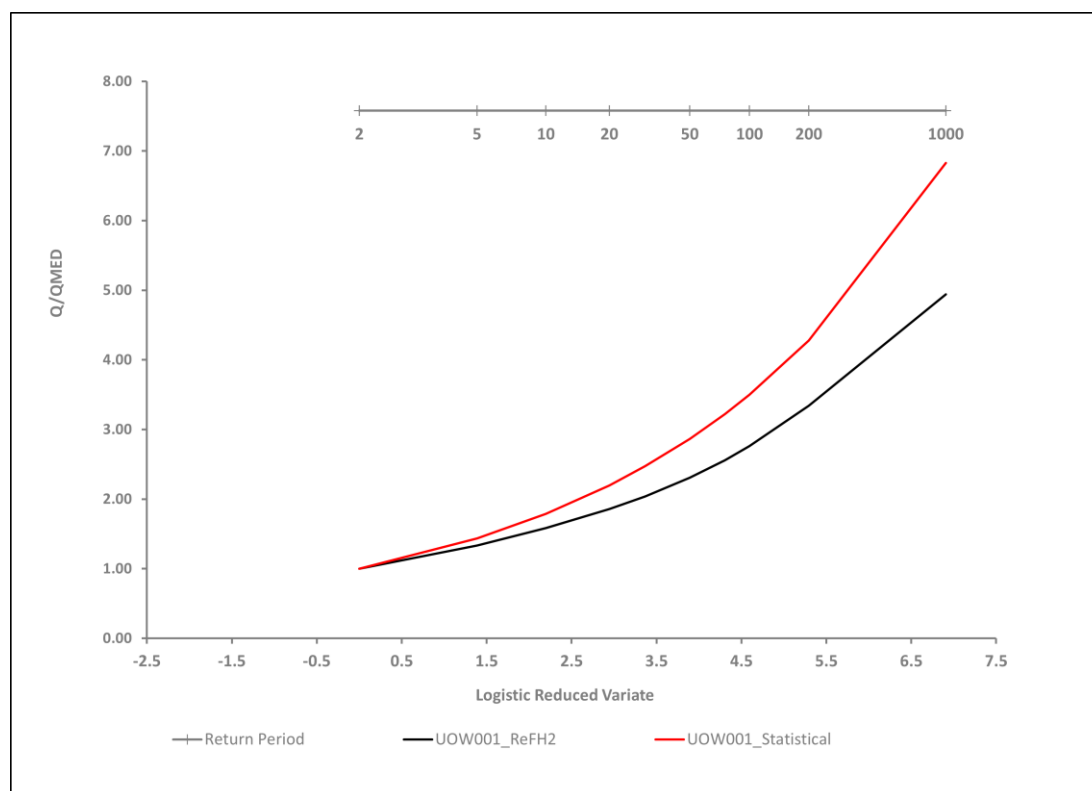


Figure 2.2: Comparison of Statistical Method and ReFH Growth Curves

- 2.30 The final choice of peak flows for input into the modelling study is the FEH Statistical method as this benefits from up-to-date flood peak data using growth curves from hydrologically similar catchments to derive a growth curve. In addition, this retains the same approach utilised within the previous hydrology assessment. ReFH2 will be used to provide a hydrograph shape.

Table 2.10: Final Peak Flows from Chosen Method (Statistical)

Site Code	Flood peak (m ³ /s) for the following return periods									
	2	5	10	20	30	50	75	100	200	1000
UOW001	0.6	0.8	1.0	1.3	1.4	1.7	1.9	2.0	2.5	3.9

- 2.31 The final peak flows have shown to generally increase when compared to the previous hydrological assessment, as shown in **Table 2.11**. These changes are thought to be due to updates to the methodology associated with the pooling groups, in particular the adjustment for non-flood years which now provides deurbanised values.

Table 2.11: Comparison of Previous Hydrology Results

Site code	1 in 2-year peak flows		1 in 100-year peak flows	
	Previous Hydrological Assessment	Updated Hydrological Assessment	Previous Hydrological Assessment	Updated Hydrological Assessment
UOW001	0.6	0.6	2.0	1.8

Application of Flows

2.32 The application of flows will be retained and is summarised below and shown in **Figure 2.3**:

- To derive hydrographs, the ReFH2 hydrographs were scaled to meet the Statistical method peak flows.
- The downstream limit of the model extent was located further upstream than the flow estimation location, and, therefore, the flows were pro-rated to cover a catchment that would drain to the extent of the watercourse that has been modelled.
- Normandy Way, located to the south of the site, represents a catchment division. Therefore, the inflows have been prorated between the upstream and downstream catchment of Normandy Way.
- Upstream of Normandy Way, the inflows were pro-rated and applied to the head of the run of each surface water sewer and the UOW.

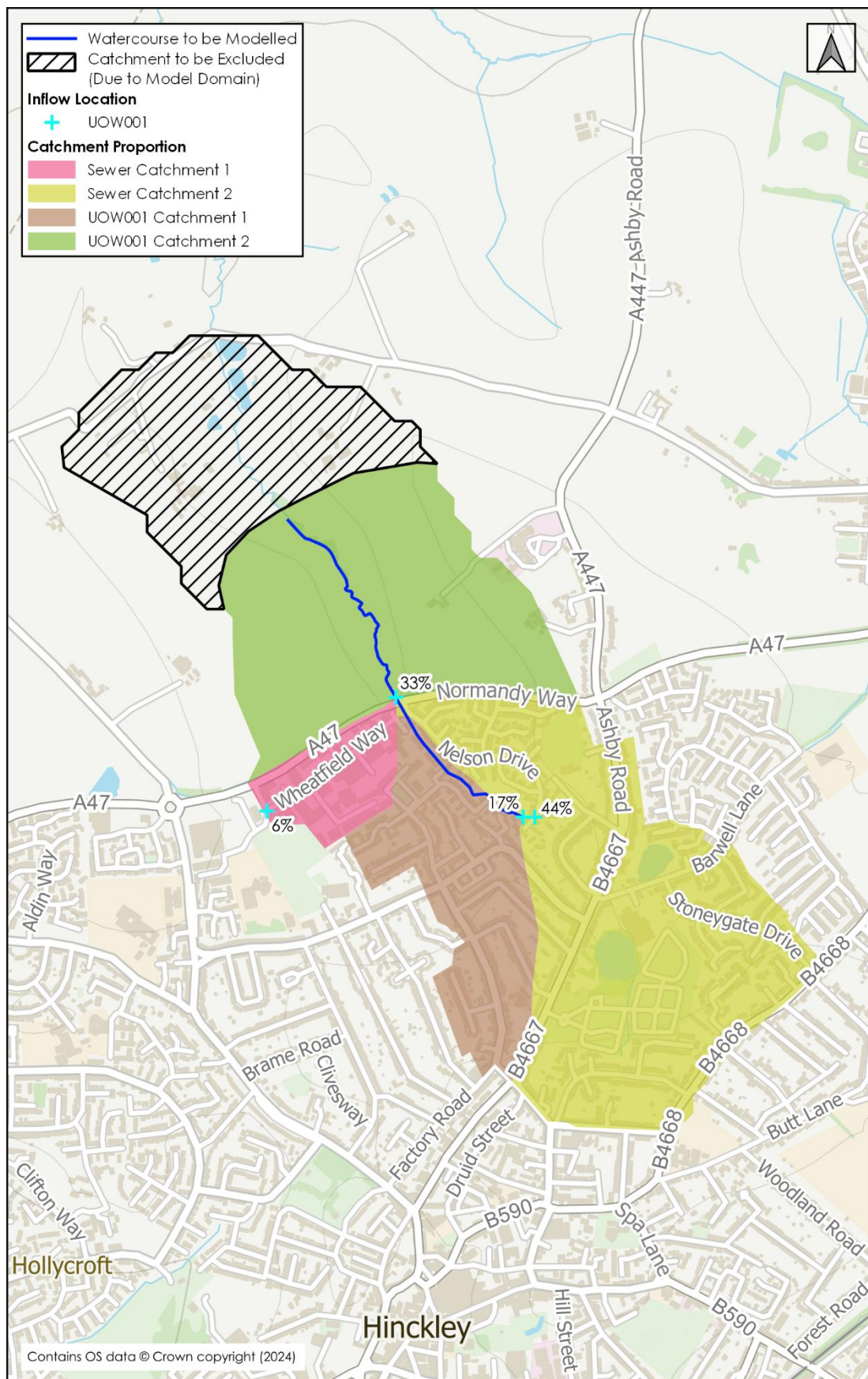


Figure 2.3: Application of Inflows

Climate Change

- 2.33 Predicted future change in peak river flows caused by climate change are provided by the EA within their online guidance⁸, with a range of projections applied to regionalised 'River Basin Districts'. These districts are further split into 'Management Catchments'. The UOW falls within the Tame Anker and Mease Management Catchment. **Table 2.12** identifies the relevant peak river flow allowances.

Table 2.12: Peak River Flow Allowance for the Tame Anker and Mease Management Catchment

Allowance Category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2125)
Upper End	24%	30%	51%
Higher Central	15%	17%	30%
Central	10%	11%	22%

- 2.34 To estimate the potential future design floodplain, the central climate change (CC) allowance for the 2080s will be applied to the 1 in 100-year flood flows. Therefore, the 1 in 100-year + 22%CC event will be simulated.

⁸ Environment Agency, Flood risk assessments: climate change allowances: <https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#table-1>

3. HYDRAULIC MODEL UPDATES

Software and Solver

- 3.1 The TUFLOW version was updated to 2023-03-AB-iDP for all model runs. TUFLOW's Classic solver was retained.

The 1D Domain

- 3.2 QT (flow vs time) boundaries were updated to represent the fluvial inflows (**Section 2**).
- 3.3 No further changes were made to the 1D domain.

1D/2D Links

- 3.4 The 1D channel was linked to the floodplain using "HX" links. These transfer the calculated water level from the 1D cross sections into the 2D floodplain, providing that the water level is above the level of the cell that the HX link is located in. Therefore, HX links should be digitised along the top of bank of the watercourse visible in LiDAR data or along the crest of any embankments if present.
- 3.5 The 1D/2D links were retained as per the previous model.

The 2D Model Domain

- 3.6 The general floodplain topography is based on the latest available LiDAR data and topographical survey.
- 3.7 The LiDAR data was updated to the 2022 version and subsequently the bank points and 2D elements of the watercourse were updated to reflect the updated LiDAR. Where watercourse survey or topographic survey data was available, this was prioritised ahead of the 2022 LiDAR data for informing top of bank levels.
- 3.8 The 2D z-shape representing the upstream channel was also increased in width from 3m to 4m in order to reduce instabilities.
- 3.9 No further changes were made to the 2D domain.

Stability, Warnings and Messages

- 3.10 TUFLOW has a number of indicators available to assess the stability of a model. These differ slightly between the Classic and HPC solver. The following indicators were checked to ensure the model was performing as expected:
- **Stage and flow time series** – A number of spot checks were completed to ensure that conveyance through the channel is as expected and that both the stage and flow time series are reasonably smooth, particularly around the study area.

- **1D negative depths** – Significant negative depths indicate that instabilities are present.
- **Cumulative Mass Error** – A value of +/-2% is considered acceptable.
- **Velocities** – Unusually high velocities or circulating vectors are usually a sign of instabilities.

- 3.11 The time series graphs were reviewed along the modelled reaches and no significant issues were present that could compromise results at the site. The river channel stages were shown to peak approximately 6 hours into the event.
- 3.12 No 1D or 2D negative depths were reported.
- 3.13 The baseline simulations reported a peak mass error within +/- 1% except for the 1 in 1000-year event. The maximum peak mass error for the 1 in 1000-year event was 2.92%. The mass error has been reviewed spatially and is shown to occur approximately 600m upstream of the site, adjacent to Nelson Drive, due to water exceeding a manhole and pooling within a topographical depression. The mass balance is not considered to have an impact on the model results at the site or the flood mechanisms informing these.

Model Runs

- 3.14 In order to achieve the study objectives, the simulations summarised in **Table 3.1** were completed.

Table 3.1: Model Runs

Model Geometry	Return Periods	Comments
Baseline Conditions	1 in 30-Year 1 in 100-Year 1 in 1000-Year 1 in 100-Year + 22%CC	Representative of existing conditions

4. BASELINE RESULTS

- 4.1 The results from the existing conditions model are mapped within **Appendix 3** and are summarised below.
- 4.2 The floodplain extents at the site have been summarised and are in **Figure 4.1** with modelled flood levels shown in **Table 4.1**.
- 4.3 As the UOW flows adjacent to the site, maximum water levels remain in-channel. Subsequently, the proposed residential development is located outside of all modelled flood extents from this watercourse.

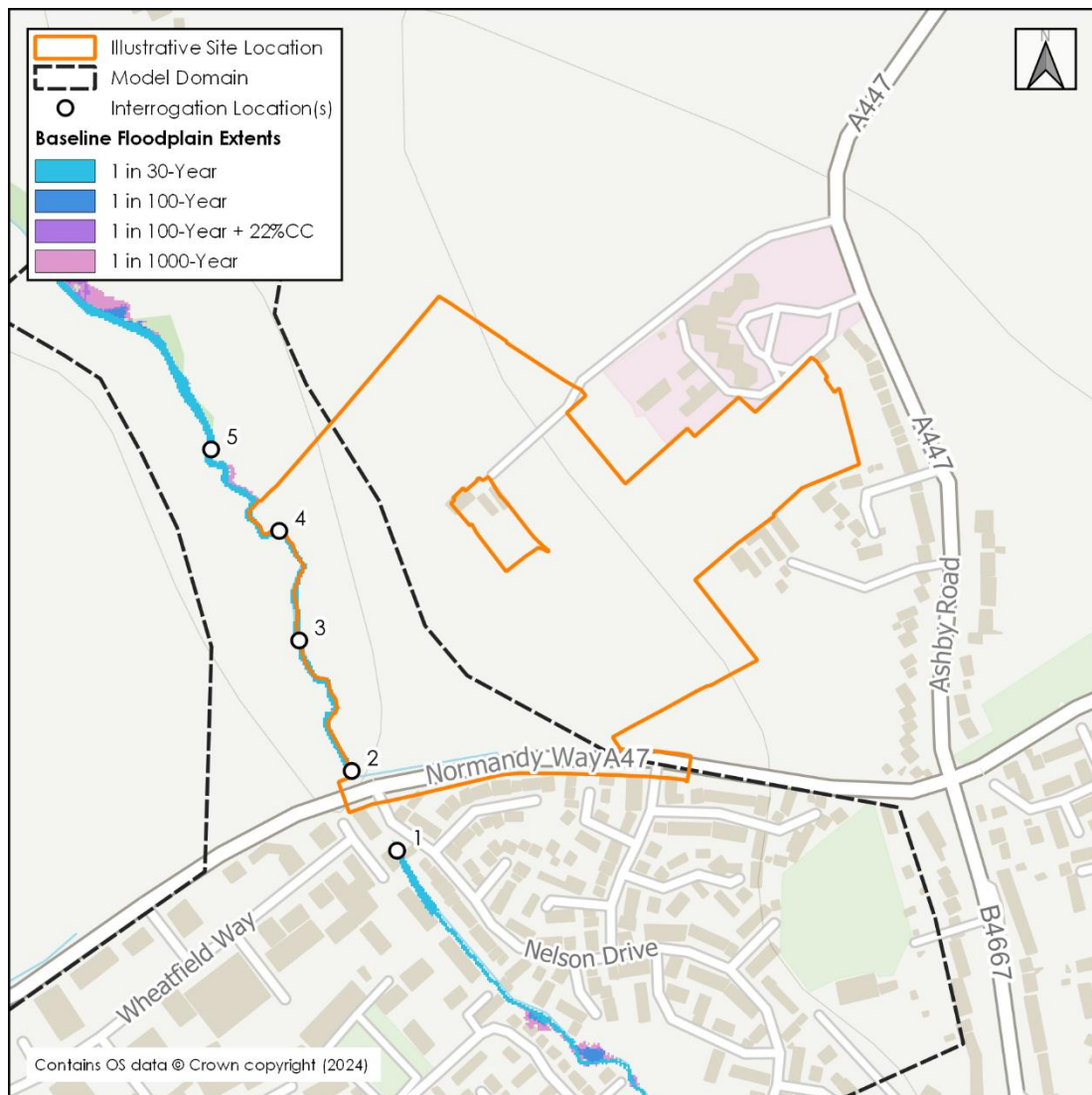


Figure 4.1: Fluvial Floodplain Extents

Table 4.1: Modelled Flood Levels (m AOD)

Node	1 in 30-Year	1 in 100-Year	1 in 100-Year + 22%CC	1 in 1000-Year
1	109.04	109.09	109.13	109.73
2	108.11	108.22	108.29	108.47
3	107.15	107.30	107.39	107.62
4	106.71	106.84	106.92	107.11
5	106.06	106.16	106.22	106.35

5. SUMMARY & RECOMMENDATIONS

- 5.1 Please note that this conclusion should be read in conjunction with the study limitations and assumptions in **Section 1**.
- 5.2 BWB Consulting Ltd has been commissioned by Richborough (the Client) to undertake updates to a hydraulic model of an UOW. The purpose of the updates is to ensure that the modelled flows are in accordance with current best practice.
- 5.3 The modelled flood flows have been informed by a hydrological review of the catchment associated with the UOW. The latest climate change allowances have been incorporated into the hydrological assessment. The final peak flows have shown to generally increase when compared to the previous hydrological assessment. These changes are thought to be due to updates to the methodology associated with the pooling groups, in particular the adjustment for non-flood years which now provides deurbanised values.
- 5.4 The model has also been updated to include for the latest LiDAR data and run in the latest software.
- 5.5 The hydraulic modelling shows maximum modelled flood levels to remain in-channel for all modelled flood extents. This is shown to align with the previous modelling undertaken, however there has been an increase in modelled flood levels due to the updated hydrology.

APPENDICES

Appendix 1: Hydraulic Model Report

ENVIRONMENT

Richborough Estates Limited and Mr & Mrs Adcock
Land East of Stoke Road and North of
Normandy Way (A47)
Hinckley
Hydraulic Model Report

ENVIRONMENT

Richborough Estates Limited and Mr & Mrs Adcock
Land East of Stoke Road and North of Normandy Way (A47)
Hinckley
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April 2022

DOCUMENT ISSUE RECORD

Document Number:	HIN-BWB-ZZ-XX-RP-YE-0002_HMR
BWB Reference:	210683_HMR

Rev	Date	Status	Comment	Author:	Checked:	Approved:
P01	31/03/22	S2	Draft Issue	Lucy Reeves BSc (Hons)	Max Brambani BSc (Hons) PgCert MCIWEM	Matthew Day BA (Hons) MSc FRGS MCIWEM C.WEM C.Sci C.Env
P02	27/04/22	S2	Addition of Proposed Development	Lucy Reeves BSc (Hons)	Max Brambani BSc (Hons) PgCert MCIWEM	Matthew Day BA (Hons) MSc FRGS MCIWEM C.WEM C.Sci C.Env

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- (i) The date on which this assessment was undertaken, and
- (ii) The date on which the final report is delivered

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All Environment Agency mapping data used under special license. Data is current as of April 2022 and is subject to change.

The information presented, and conclusions drawn, are based on statistical data and are for guidance purposes only. The study provides no guarantee against flooding of the study site or elsewhere, nor of the absolute accuracy of water levels, flow rates and associated probabilities.

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GLOSSARY & NOTATION

1D – one-dimensional hydraulic model, good for representing the hydraulics of a definitive channel or flow pathway and hydraulic structure.

2D – two-dimensional hydraulic model, good for representing complex flow routing present within the floodplain.

Annual Exceedance Probability (AEP) - the probability (%) of a flood event occurring in any year.

Catchment - the land area that drains (normally naturally) to a given point on a river, drainage system or body of water.

Design flood event - magnitude of the flood adopted for the design of the whole or part of a development, usually defined in relation to the severity of the flood in terms of its return period. Typically, the 1 in 100-year return period event including an allowance for future climate change for fluvial flood events.

DTM – Digital Terrain Model

EA – Environment Agency

ESTRY - a 1D hydraulic modelling software package published by BMT.

Flood Estimation Handbook (FEH) – industry standard guidance on rainfall and river flood frequency estimation across the UK.

Floodplain - any area of land over which water flows or is stored during a flood event.

FRA – Flood Risk Assessment

Freeboard - the height of the top of a bank, floodwall or other flood defence structure, above the design water level. Freeboard can be seen as a safety margin that makes allowance for uncertainty associated with the potentially damaging effects of flood rise or wave action.

Hydraulic Model - a mathematical (generally computer based) model of a water/sewer/storm system which is used to analyse the system's hydraulic behaviour.

LiDAR – Light Detection and Ranging aerial survey data

LLFA – Lead Local Flood Authority

mAOD – metres above Ordnance Datum

m BGL – metres below ground level

Main River - a statutory type of watercourse in England and Wales, usually larger streams and rivers. The EA can carry out maintenance, improvement or construction work on main rivers to manage flood risk as part of its duties and powers.

NRFA – National River Flow Archive

OS – Ordnance Survey

Preliminary Flood Risk Assessment (PFRA) - an assessment of floods that have taken place in the past and floods that could take place in the future. It generally considers flooding from surface water runoff, groundwater and ordinary watercourses, and is prepared by the Lead Local Flood Authority.

ReFH – Revitalised Flood Hydrograph rainfall-runoff hydrological model

Return period - a statistical term defining the probability of occurrence of a flood event. Thus a 1 in 50-year flood is one likely to be equalled or exceeded on average only once in a 50-year period: a flood with a 2.0% annual probability exceedance (AEP).

Strategic Flood Risk Assessment (SFRA) - a study carried out by one or more local planning authorities to assess the risk to an area from flooding from all sources, now and in the future.

TUFLOW – a 2D fixed grid hydraulic modelling software package published by BMT.

UOW – Unnamed Ordinary Watercourse

Watercourse – a natural or man-made open channel for the conveyance of water.

Z-line – a break line layer in TUFLOW which can be used to reinforce linear features in the 2D model domain such as a riverbank, flood defence, or channel bed.

Z-Shape – a layer in TUFLOW which can be used to manipulate the 2D model geometry.

1. INTRODUCTION

- 1.1 BWB Consulting Ltd has been commissioned by Richborough Estates Limited and Mr & Mrs Adcock to undertake a site-specific hydraulic modelling exercise of an Unnamed Ordinary Watercourse (UOW) and a series of ditches to support a proposed residential development at the Land East of Stoke Road and North of Normandy Way, Hinckley (NGR: SP419956).

Aims and Objectives.

- 1.2 This modelling exercise will be used to establish a good hydrological and hydraulic representation of the flooding mechanisms to the site and within the wider vicinity. Modelled floodplain extents and flood levels will be used to support a Flood Risk Assessment (FRA). The following objectives have been identified:
- i. Undertake a hydrological review of the Unnamed Ordinary Watercourse and ditches within the vicinity of the site to estimate peak flows and general flood hydrograph profiles.
 - ii. Construct a one-dimensional (1D) representation of the in-channel environment, where topographical survey is available, including structures using ESTRY software.
 - iii. Construct a two-dimensional (2D) representation of the floodplain using TUFLOW software.
 - iv. Combine and link the 1D and 2D model domains.
 - v. Undertake simulations of key flood return period events to understand the floodplain extents and peak flood levels within and adjacent to the site.
 - vi. Undertake simulations to account for climate change flows within the model.
 - vii. Undertake sensitivity analysis of baseline conditions.

Approach

- 1.3 In order to achieve the objectives identified above, a new 1D/2D ESTRY-TUFLOW model was constructed, based on a watercourse survey completed by BWB Consulting Ltd in February 2022 (Reference: HIN-BWB-ZZ-M2-G-0060, see **Appendix 1**).
- 1.4 The model has been simulated for a series of design storm events. These modelled events include the 1 in 20-year, 1 in 100-year and 1 in 1000-year events that are typically used by the Environment Agency (EA) for planning purposes to define Flood Zones 3b, 3a and 2 respectively.
- 1.5 Simulations have been run to account for the impacts of climate change in accordance with the allowances released by the EA in July 2021. This is necessary so that the FRA can assess the risk of flooding to the proposed development over the length of the anticipated lifetime.
- 1.6 Sensitivity testing has also been undertaken to understand what impacts changes to roughness and downstream boundary has upon the model outputs and to increase confidence in the outputs of the hydraulic modelling.

- 1.7 The modelled flood extents and peak water levels from this study have been assessed in the associated FRA (reference: HIN-BWB-ZZ-XX-RP-YE-0003). Following an assessment of the development proposals, appropriate development levels and mitigation measures have been recommended as part of the FRA.

Site Description

- 1.8 The site is located approximately 1.7km north of Hinckley town centre. The site is bound to the north by agricultural land, to the east by an Unnamed Ordinary Watercourse (UOW) to the south by Normandy Way (A47) and to the west by a pond and further greenfield land. Stoke Road is shown to pass through the site boundary.
- 1.9 The site location is shown in **Figure 1.1**.

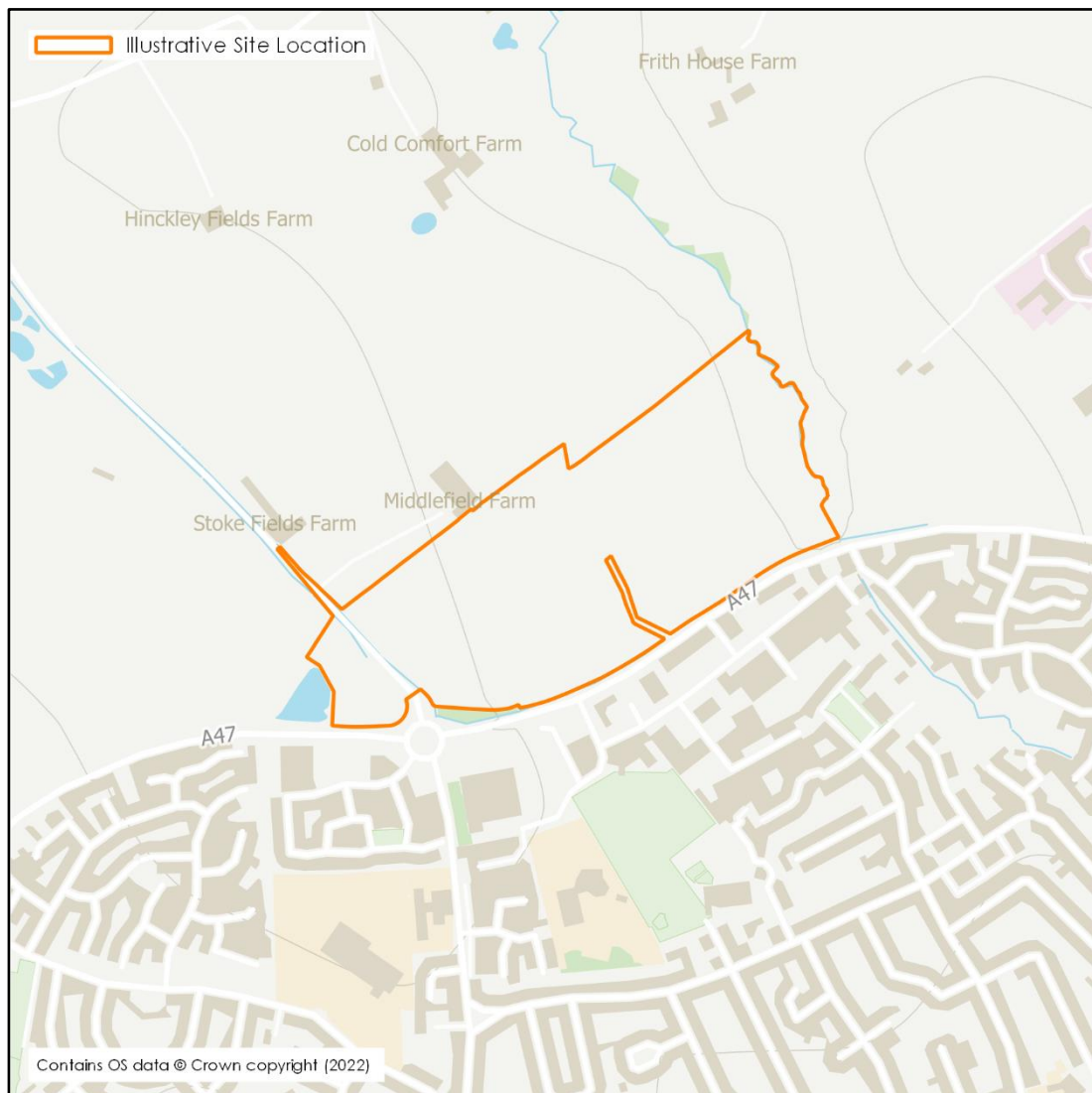


Figure 1.1: Site location

- 1.10 A topographical survey has been undertaken to inform the study. The land parcel to the west of Stoke Road is shown to generally fall in a northerly direction. Site levels are shown

to range from approximately 106.1 metres Above Ordnance Datum (mAOD) in the south to approximately 104.5mAOD in the north.

- 1.11 Ground levels across the main land parcel rise away from Stoke Road to the west and the UOW to the east. The centre of the site subsequently forms a topographical high point, defining a split between two catchments. Site levels within the eastern catchment are shown to range from approximately 119.0mAOD at the centre of the site to approximately 106.5mAOD in the north east. Site levels within the western catchment are shown to range from approximately 119.0mAOD to 104.8mAOD in the north west. The site contours are displayed in **Figure 1.2**.

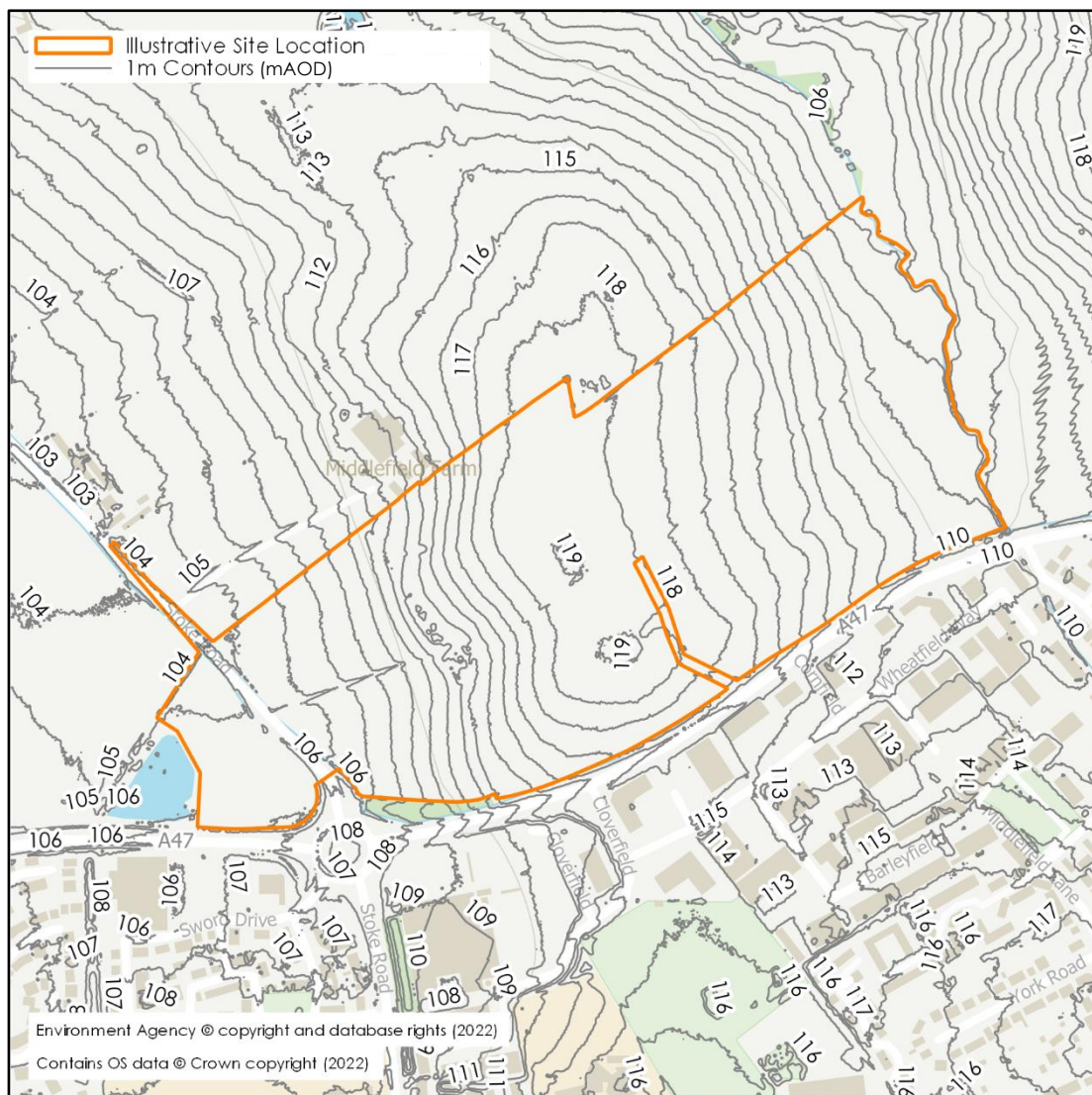


Figure 1.2: Site Topography

Local Watercourses

- 1.12 An Unnamed Ordinary Watercourse (UOW) flows along the eastern boundary of the site in a northerly direction. The watercourse is a tributary of the River Tweed. The UOW flows from within the urban development to the south of the site via twin 0.5m diameter circular culverts beneath Normandy Way. The UOW then flows adjacent to the

perimeter of the site as an open channel. Severn Trent Water sewer records demonstrate that two surface water sewers, that drain residential areas in the upper limits of the catchment, outfall to the river immediately downstream of Normandy Way.

- 1.13 A series of ditches/highway drains are shown to be located within the vicinity of Stoke Road at the western portion of the site boundary. Two of the ditches (R2 & R3) are shown to flow adjacent to either side of Stoke Road in a north westerly direction. A further ditch (R4) is shown to flow towards Stoke Road from Normandy Way and is assumed to outfall to the ditch (R2) immediately east of Stoke Road.
- 1.14 The ditches are understood to be fed by surface water sewers originating within the urban development to the south of Normandy Way and are therefore considered to be more representative of surface water flooding mechanisms.
- 1.15 **Figure 1.3** shows the local watercourse network. The watercourse labels shown will be referenced throughout this report with R2, R3 and R4, as a collective, referred to as the 'western ditches'.

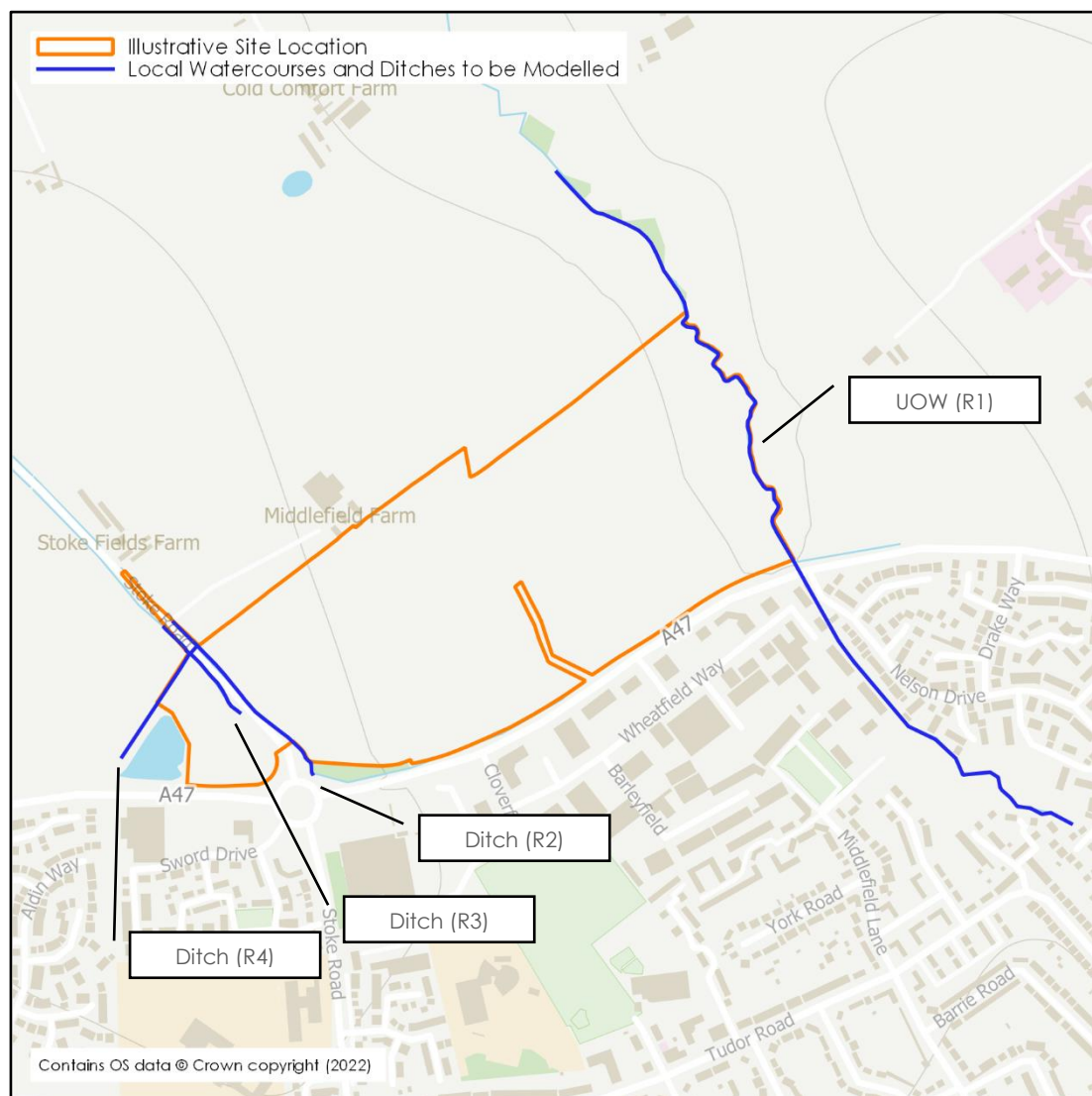


Figure 1.3: Watercourse Network

- 1.16 The UOW (R1) has a total catchment area of approximately 2.1km², R2 and R3 have a catchment area of 0.7km² and R4 has a catchment area of 0.3km². The watercourses and ditches are fed by surface water sewers, which outfall to the waterbodies downstream of Normandy Way. The modelled catchments are displayed in **Figure 1.4**.

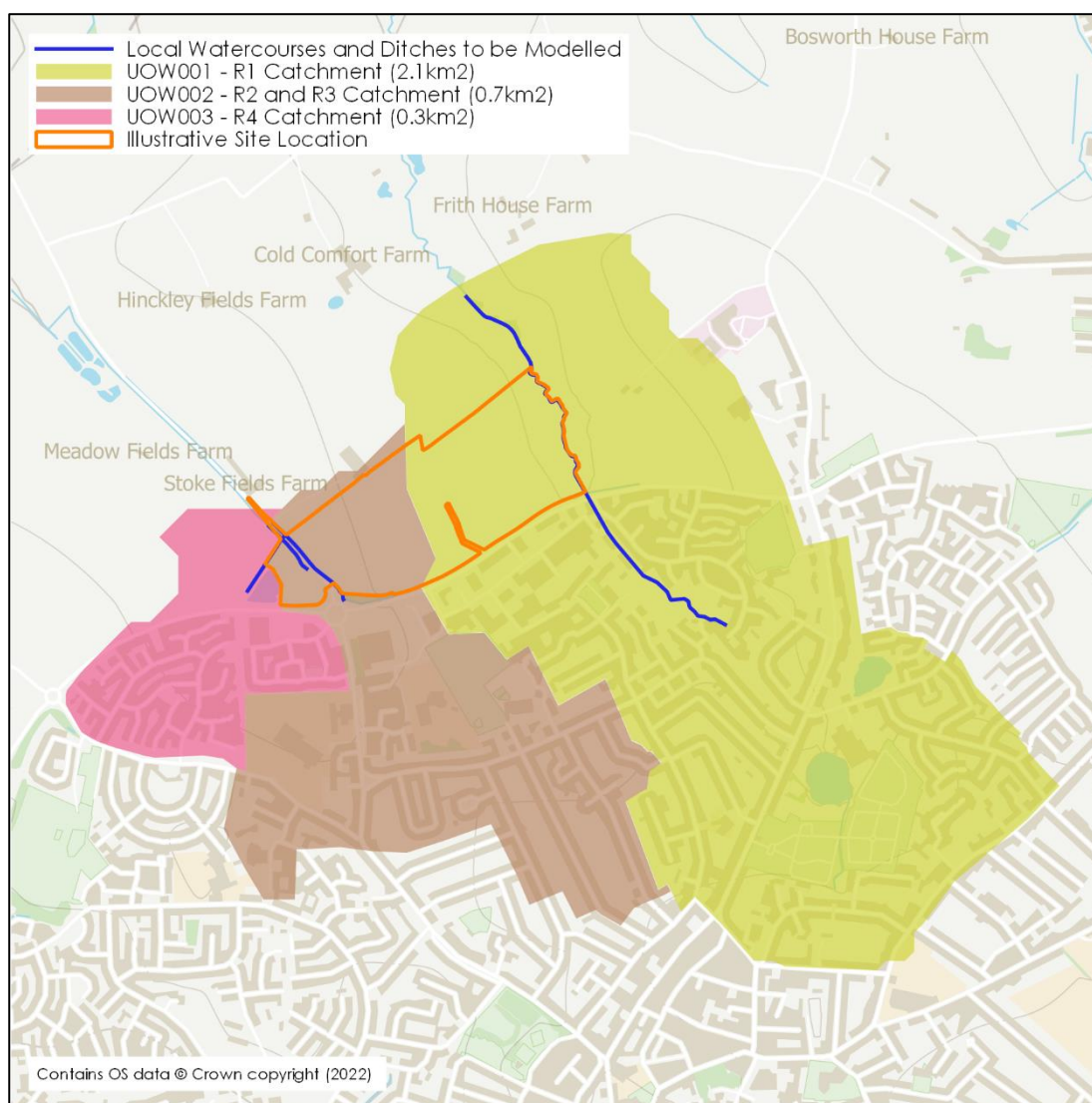


Figure 1.4: Modelled Catchment Areas

Previous Studies & Available Data

Historic Flood Events

- 1.17 A flood history review for the catchment has been undertaken using EA recorded flood outlines, Hinckley and Bosworth Borough Council Level 1 Strategic Flood Risk Assessment (SFRA)¹, Hinckley and Bosworth Borough Council Level 2 SFRA², Leicestershire County Council Preliminary Flood Risk Assessment (PFRA)³, Leicestershire

¹ Level 1 Strategic Flood Risk Assessment (JBA Consulting, July 2019)

² Level 2 Strategic Flood Risk Assessment (JBA Consulting, May 2020)

³ Preliminary Flood Risk Assessment (Leicestershire County Council, June 2011)

County Council Local Flood Risk Management Strategy (LFRMS)⁴, the British Chronology of Hydrological Events and online newspaper records.

- 1.18 The Level 1 SFRA notes that a surface water overland flow route exists along Stoke Road and is associated with an unnamed drain adjacent to this road, however there are no historic flooding incidents recorded. It is unknown whether this surface water flow route affects the development site.
- 1.19 The Environment Agency (EA) recorded flood outline information does not include any historical records within proximity of the site. Given the greenfield nature of the site and lack of receptors, this does not necessarily mean that the site has never flooded.
- 1.20 Following consultation with Severn Trent Water, it was confirmed that no information is held on ditches R2, R3 and R4. It was stated, however, that whilst no locations of flooding have been identified, they are aware of capacity issues regarding the surface water sewer network within this area.

BWB Site Visit (January 2022)

- 1.21 A site visit was undertaken by BWB during January 2022 to walk the local watercourse reaches and observe any key features that either needed surveying or needed to be considered during the hydraulic modelling process. The key considerations have been summarised below:
 - The UOW (R1) to the east of the site flows in a northerly direction. A brick arch structure was observed looking upstream towards the culvert beneath Normandy Way. Adjacent to the site, the watercourse follows the site boundary as open channel with some small structures along this reach.
 - The ditch located immediately east of Stoke Road (R2) is shown to be culverted at the head of the reach. It was not possible to trace back to an open reach of the watercourse within the town of Hinckley, with manholes notable at the Morrisons car park on the southern side of Normandy Way.
 - A detention basin is located adjacent to R4. No outfall from the detention basin could be identified due to access restrictions within this part of the site. It is assumed that the basin likely discharges into R4, the adjacent ditch.
 - The upstream limit of R3 appeared dry at the time of the site visit.

Environment Agency Flood Maps

- 1.22 The EA Flood Map for Planning confirms the site as being located entirely within Flood Zone 1. This is likely to be due to the smaller catchments associated with the UOW and ditches which means they have been excluded from the national scale mapping. Subsequently, no existing detailed model information is held by the EA at the site.
- 1.23 The closest Flood Zones to the site are located approximately 1.3km downstream. The Flood Map is displayed in **Figure 1.5**.

⁴Local Flood Risk Management Strategy (Leicestershire County Council, August 2015)

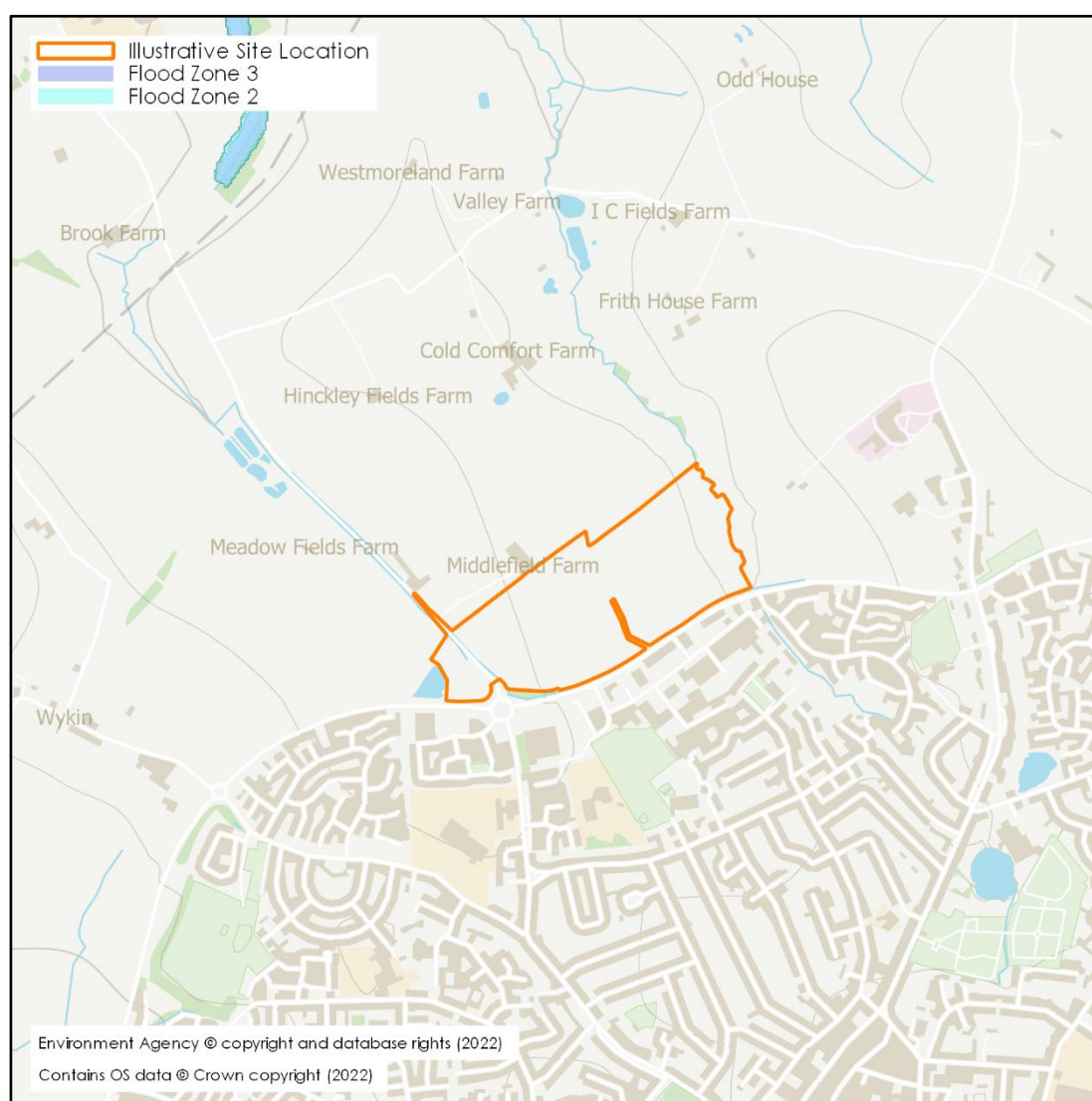


Figure 1.5: EA Flood Map

Environment Agency Surface Water Maps

- 1.24 The EA Risk of Flooding from Surface Water mapping provides an indication of the floodplain associated with ordinary watercourses that are not included in the Flood Map for Planning. The surface water mapping is included within **Figure 1.6**.
- 1.25 The mapping shows that pluvial flow routes overtop Normandy Way (A47) both upstream of the UOW (R1) and the western ditches. The surface water extent along R2 is relatively contained to the capacity of the channel with some out of bank flooding predicted at lower ground levels immediately adjacent to the site and downstream of the site. Isolated areas of surface water flooding are seen in the site which are attributed to existing hedgerows (with drainage ditches) and a pond/topographical depression in the centre of the site. The field between the existing detention basin and Stoke Road is predicted to convey overtopping surface water from Normandy Way into R3 and R4.

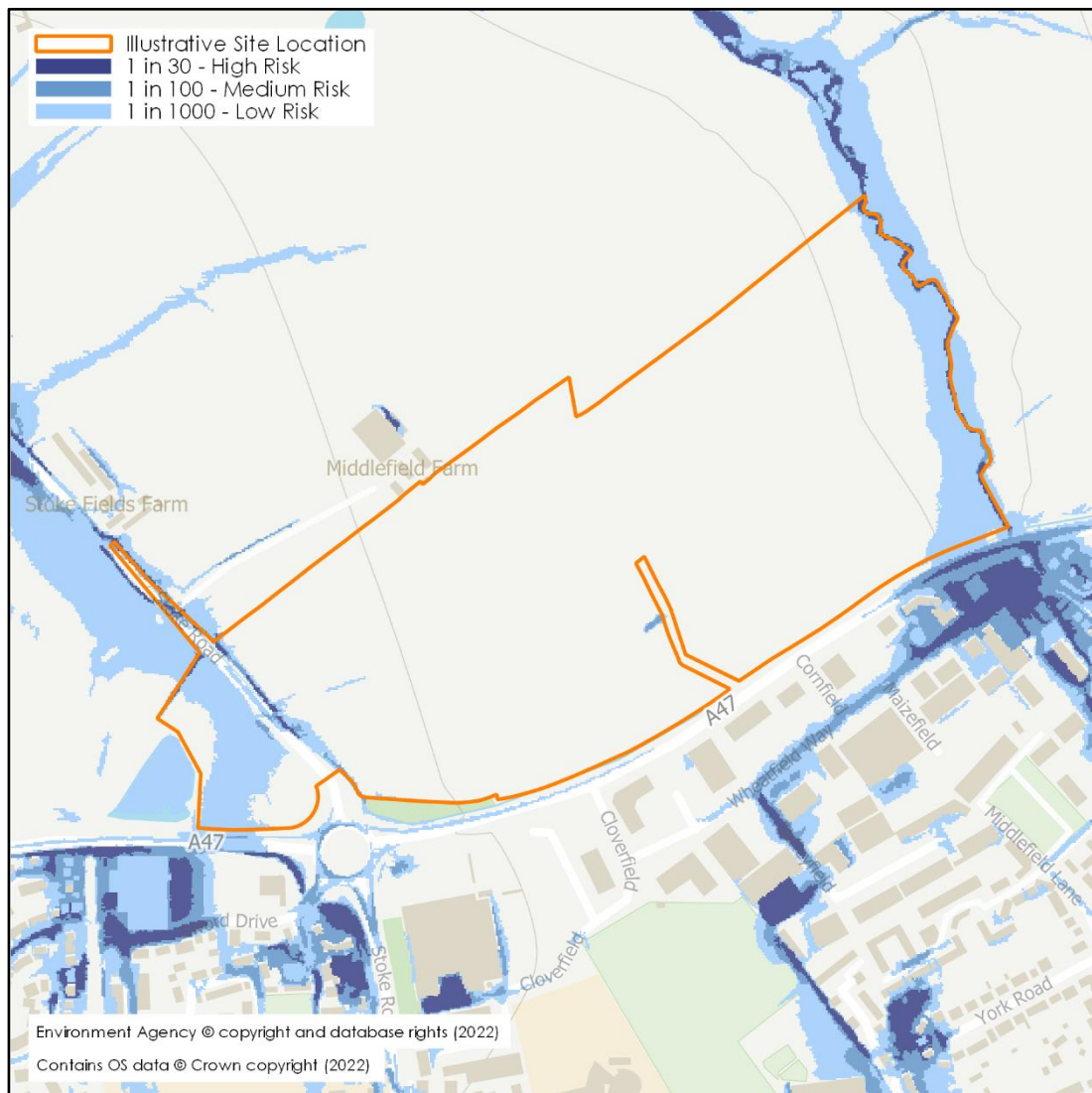


Figure 1.6: EA Risk of Flooding from Surface Water

- 1.26 Given that surface water flooding is also predicted to overtop Normandy Way at the UOW (R1), out of bank flooding is also predicted within the site at the eastern boundary for the larger magnitude (1 in 1000-year) storm event. Notable surface water flooding is predicted within urban areas of Hinckley upstream of both the UOW (R1) and the western ditches, which aligns with the capacity issues of the existing sewer network (as identified by Severn Trent Water). However, the surface water mapping does not explicitly represent culverts and structures and therefore is expected to provide a conservative representation of surface water flood risk at the site.

Other Sources of Data

- 1.27 The following additional datasets were used within the hydraulic modelling exercise:
- EA Light Detection and Ranging (LiDAR) 2020 1m Digital Terrain Model (DTM).
 - Topographical survey (reference: 42117_T_REV0), undertaken in November 2021.
 - Cross-sectional Watercourse Survey, undertaken in February 2022 (**Appendix 1**).

- Photographs and observations from the site visit undertaken in January 2022 by BWB Consulting.
- A hydrological assessment of flood flows undertaken by BWB Consulting (**Appendix 2**).

Assumptions and Limitations

1.28 Several assumptions were made during the study which may lead to implications on the modelled results. However, the study has been based on the data available at the time of writing. The key assumptions and limitations are as follows:

- The modelling exercise has made use of the available data at the time of construction and simulation. The model represents the floodplain and channel conditions at the time of survey.
- The model contains no formal representation of the conveyance within minor watercourses or ditches other than that captured by the model grid and within the 1D model domain.
- The 2m resolution of the model may negate any small-scale topographic features, although all the significant features are believed to have been captured.
- Some of the floodplain levels are derived from LiDAR which has limited accuracy ($\pm 0.15\text{m}$). however, this is considered to be sufficient for the purpose of this study.
- The bare earth DTM does not include for the presence of walls, buildings or other structures. Buildings have been modelled at ground level with an elevated roughness in line with best practice.
- The modelling exercise has been undertaken to produce a good representation of flood risk mechanisms in and around the study site. It has not been designed to accurately map flooding in the wider catchment.
- An assessment of OS mapping, LiDAR and sewer records was undertaken to determine the extent of the upstream catchment areas that drain to the watercourse and ditches that have been assessed as part of this study.
- The culvert at the end of R4 has been assumed to discharge beneath Stoke Road into R2 so that levels maintain a constant gradient. A CCTV survey will be required to confirm the exact culvert outlet location.
- Sewer manhole cover levels have been based off Severn Trent Water sewer records in the catchment upstream of the UOW (R1). An alternative approach has been adopted in the catchment upstream of the ditches, whereby cover levels are determined off the respective ground level informed by the 1m LiDAR data at this location. This was to overcome off-site model instabilities.
- It is assumed that Severn Trent Water sewer records can be relied upon to represent the network surrounding the site and no CCTV survey has been undertaken at this time to verify the outputs.
- All manholes are assumed to have a diameter of 0.5m with the diameter of any pipes taken from Severn Trent Water Sewer records.
- It is assumed that all sewers are clear from any blockages/sedimentation.
- Only the primary trunk sewer runs have been represented within the model. No secondary networks or private drainage have been included which may alter the timing and distribution of flows.

- The existing topographical survey has been used to derive the proposed access road level in the absence of design levels.

2. HYDROLOGY

Flood Flow Estimation

- 2.1 A hydrological review of the catchment was undertaken using Flood Estimation Handbook (FEH) methodologies to estimate peak flood flows and derive an appropriate hydrograph shape. This was undertaken in relation to the EA's latest guidance⁵. This assessment is documented within **Appendix 2**. For the purpose of the hydrological assessment, all features have been given a UOW site code prefix as detailed within **Table 2.1**.

Table 2.1: Naming Convention

Modelling Naming Convention	Hydrology Naming Convention
UOW (R1)	UOW001
Ditch (R2)	UOW002
Ditch (R4)	UOW003

- 2.2 In summary, there was no hydrometric data available in the area to inform the hydrological analysis. Therefore, the industry standard FEH statistical method and Revitalised Flood Hydrograph (ReFH2.3) rainfall-runoff model were both reviewed, and a comparative analysis undertaken.
- 2.3 The final choice of peak flows for input into the model for the UOW was the FEH Statistical Method as it benefits from an up-to-date flood peak dataset, using growth curves from hydrologically similar catchments to derive a growth curve. The Statistical Method also benefits by avoiding the need to make assumptions about factors such as rainfall duration, time of concentration and the nature of the design flood, unlike the ReFH2 method.
- 2.4 ReFH2 was used to provide a hydrograph shape for the model inflows for the UOW (R1), scaled to the Statistical peak.
- 2.5 The final choice of peak flows for input into the model for the ditches is the ReFH2 Method, due to the influence of sewers at the upstream extent of the watercourses.
- 2.6 A full record of the hydrological analysis can be found in **Appendix 2**.
- 2.7 The final inflows incorporated into the model are summarised within **Table 2.2**. **Figure 2.1** demonstrates how the flows will be applied to the model. For UOW001, the model extent was located further upstream than the flow estimation location and therefore the flows detailed in **Table 2.2** were pro-rated to cover a catchment that would drain to the extent of the watercourse that has been modelled.

⁵ Flood Estimation Guidelines 197_08 (Environment Agency, June 2020)

Table 2.2: Adopted Peak Flood Flows

Return Period Event (Yrs)	Annual Exceedance Probability (AEP)	Catchment Peak Flow – UOW001 (m ³ /s)	Catchment Peak Flow – UOW002 (m ³ /s)	Catchment Peak Flow – UOW003(m ³ /s)
1 in 2	50%	0.6	0.3	0.2
1 in 5	20%	0.8	0.5	0.2
1 in 10	10%	1.0	0.6	0.3
1 in 20	3.3%	1.2	0.7	0.3
1 in 50	2.0%	1.5	0.8	0.4
1 in 75	1.3%	1.7	0.9	0.5
1 in 100	1.0%	1.8	1.0	0.5
1 in 200	0.5%	2.2	1.3	0.6
1 in 1000	0.1%	3.5	2.0	1.0

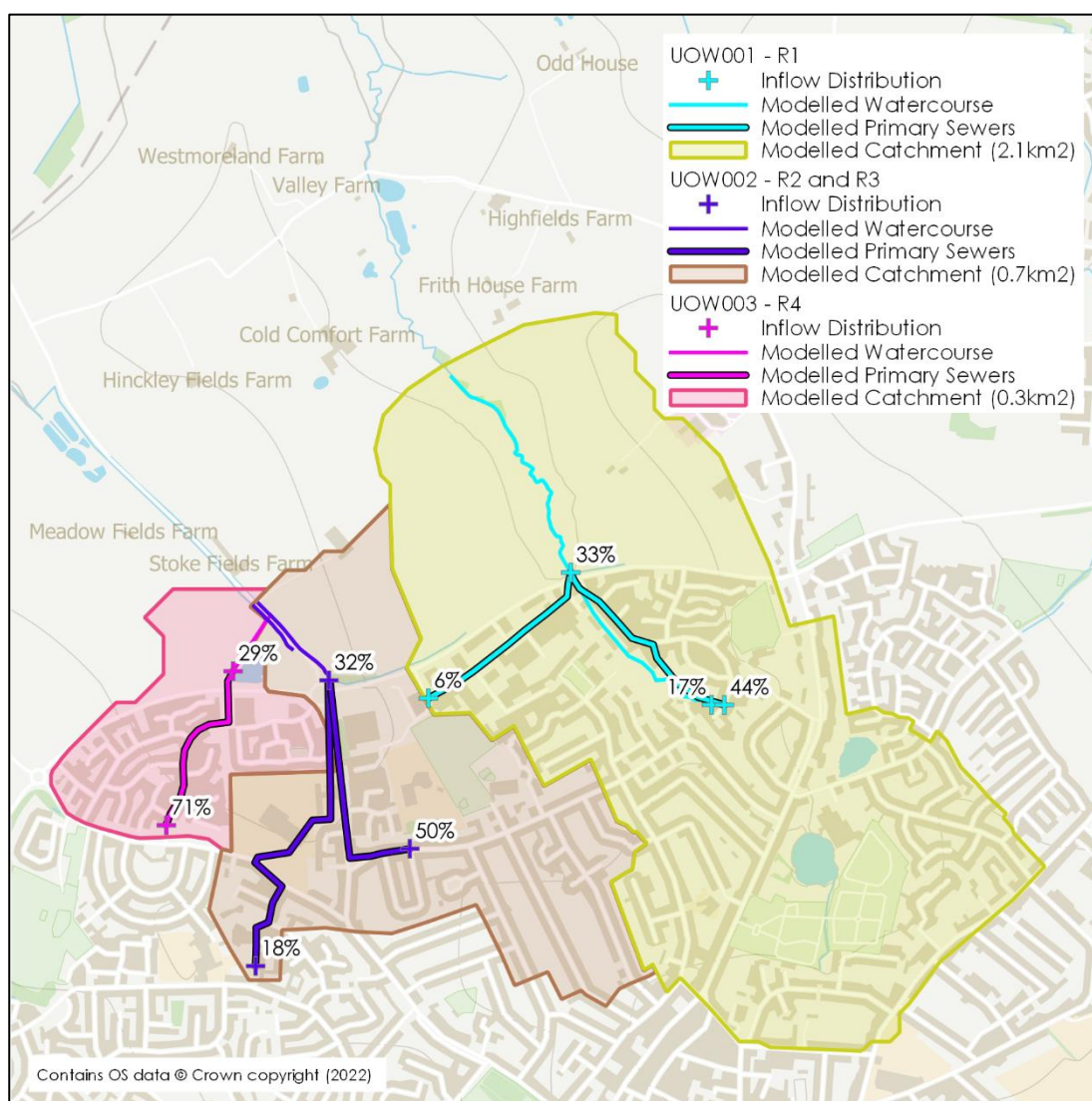


Figure 2.1: Distribution of Model Inflows

Climate Change

- 2.8 Predicted future change in peak river flows caused by climate change are provided by the EA within their online guidance⁶, with a range of projections applied to regionalised 'River Basin Districts'. These districts are further split into 'Management Catchments'.
- 2.9 The study area falls within the Tame Anker and Mease Management Catchment of the Humber River Basin District. **Table 2.3** identifies the relevant peak river flow allowances.

Table 2.3: Peak River Flow Allowance for the Tame Anker and Mease Management Catchment

Allowance Category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2125)
Upper End	24%	30%	51%
Higher Central	15%	17%	30%
Central	10%	11%	22%

- 2.10 To estimate the potential future design floodplain under a range of scenarios, the Central climate change allowance for the 2080s will be applied to the 1 in 100-year flood flows. The design event is subsequently the 1 in 100-year +22% climate change (CC) event.

⁶ Environment Agency, Flood risk assessments: climate change allowances: <https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#table-1>

3. THE HYDRAULIC MODEL

Software and Solver

- 3.1 A combination of TUFLOW version 2020-10-AC-iDP and 2020-10-AB-iDP was used for all model runs. TUFLOW's Classic solver was used.
- 3.2 TUFLOW's built in 1D component, ESTRY, was used to model the 1D domain/channel.

The 1D Domain

Extent

- 3.3 The 1D domain for the western ditches begins from within the site boundary. The ditches are represented within the 1D domain until the downstream boundary. A Model Schematic is included as **Appendix 4**.
- 3.4 The 1D domain for the UOW (R1) begins upstream of the site, to the rear of the dwellings located along Nelson Drive. The majority of the channel is represented within the 1D domain, however the first 400m of watercourse is modelled within the 2D domain.
- 3.5 The public sewers, as shown on Severn Trent Water sewer records, have been identified as discharging to the eastern UOW and western ditches. Accordingly, relevant areas of the public sewer network were represented within the 1D domain. Only the trunk sewers that drain towards to the watercourses/ditches were incorporated within the model. No private sewer networks or secondary networks have been included within the model.
- 3.6 The inclusion of the main sewer runs in the model provides a representation of how the flows are routed through the drainage system before outfalling to the watercourse and ditches. In addition, this allows for an assessment of constraints introduced by the insufficient capacity of the sewer network upstream of the site.
- 3.7 In order to represent the interaction between the subsurface sewer network and the surface, manhole locations (as identified by Severn Trent Water sewer asset records) were represented in the model using a "1d_pits" layer.
- 3.8 Each manhole was provided an assumed diameter of 0.5m. The surface levels in the sewer network associated with the UOW (R1) were defined by cover levels provided by Severn Trent. For the sewer network upstream of the western ditches, 1m LiDAR data was used to inform the manhole surface levels. This different approach was considered necessary to overcome off-site model instabilities that were caused by a disagreement between the Severn Trent cover levels and 2D ZC levels of surrounding cells, as defined by the 1m LiDAR.
- 3.9 The model domain is shown in **Figure 3.1** and as a Model Schematic included as **Appendix 4**.

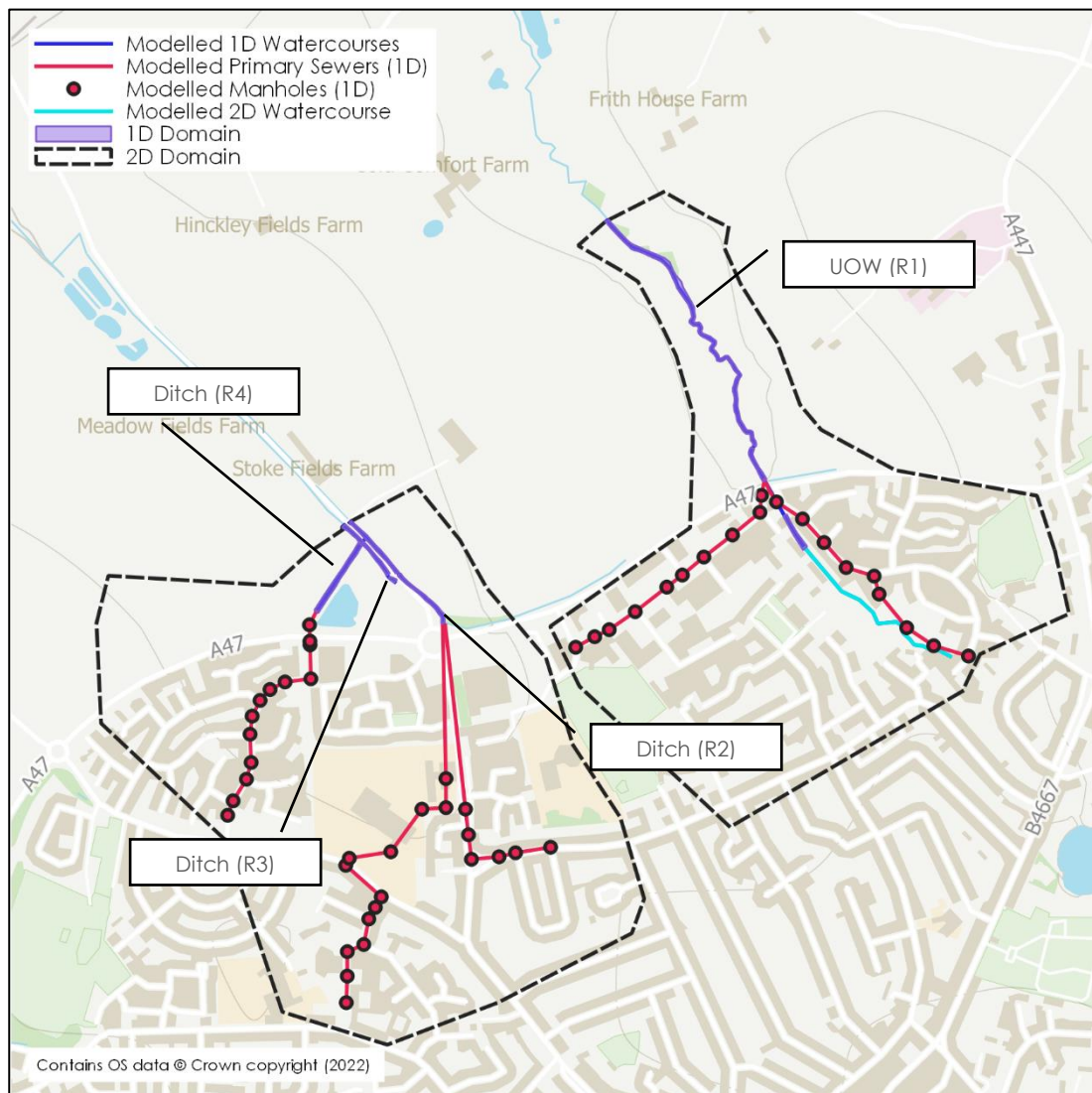


Figure 3.1: Modelled Watercourses, Sewers and Domain Extents

Channel Geometry

- 3.10 The river channel geometry is based on a new watercourse survey carried out by BWB Consulting in February 2022. The survey also captured hydraulic structures that were present such as bridges and culverts.
- 3.11 The maximum distance between cross sections is 125m. However, sections are more generally spaced 45m-80m apart. The river channel survey is available as **Appendix 1**.
- 3.12 The channel sections were truncated at top-of-bank from survey data, at what would be the interface with the 2D domain.

Hydraulic Roughness

- 3.13 Hydraulic roughness has been represented using the Manning's n coefficient. The values applied are based on those stipulated in the literature, using Chow (1959)⁷. This study documents appropriate values based on channel bed material, sinuosity and presence of vegetation.
- 3.14 The guideline values are chosen using engineering judgement, based on photographs of the channel condition taken at the time of survey. Each cross section has a Manning's roughness value applied in the same way as the channel geometry and is read into TUFLOW within a CSV file.
- 3.15 The bed of the eastern UOW and ditches were generally clean and winding with pools and riffles and light bank vegetation. The bank vegetation varied across the sections, however predominately areas were considered to be either highly vegetated around hedgerows with lower roughness values assigned where grass was present. Some examples are highlighted in **Table 3.1** below.

Table 3.1: Manning's n examples

Model ID	Values chosen and description	Photograph
UOW001_00769	0.04 Main Channels Clean, but winding with pools and riffles, light bank vegetation	

⁷ http://www.fsl.orst.edu/geowater/FX3/help/8_Hydraulic_Reference/Mannings_n_Tables.htm

Model ID	Values chosen and description	Photograph
R4_00023	0.03 Floodplains Grass, short	
R2_00077	0.06 Floodplains Trees – medium density with sprouts	

Hydraulic Structures

- 3.16 A number of hydraulic structures were represented in the 1D domain, the data for which was collected during the watercourse survey.
- 3.17 In total, 6 circular culverts and 2 irregular culverts were included in the model, the details of which are included as **Appendix 3**.

Boundary Conditions

- 3.18 Boundary conditions were applied to the 1D domain to both allow flow in and out of the model.
- 3.19 QT (flow vs time) boundaries were used to represent the fluvial inflows (**Section 2**) as hydrographs. These consisted of point inflows at the upstream extents of the watercourses and sewers and at the downstream extent of any intervening

topography (i.e. Normandy Way). **Figure 2.1** shows where these boundaries were applied.

- 3.20 A HT (water level vs time) boundary was applied at the downstream limit of the 1D domain. This was set to 104.77mAOD for the UOW (R1) which is the surveyed top of bank at the downstream cross section (UOW001_00702), 103.85mAOD for R2 which is the surveyed water level at the downstream cross section (R2_00000) and 104.05m AOD for R3 which is between the top of bank and bed level of the downstream cross section (R3_00000).

1D/2D Links

- 3.21 The 1D channel was linked to the floodplain using “HX” links. These transfer the calculated water level from the 1D cross sections into the 2D floodplain, providing that the water level is above the level of the cell that the HX link is located in. Therefore, HX links should be digitised along the top of bank of the watercourse visible in LiDAR data or along the crest of any embankments if present.
- 3.22 In order to represent the interaction between the subsurface sewer network and the 2D domain, manholes were represented in the model using a “1d_pits” layer. A “SXZ” command is utilised in the 1d_pits layer to allow water to spill from the manhole into the 2D domain and vice versa.
- 3.23 The average modelled width of the channel was approximately 6-8m.

The 2D Model Domain

Extent and Active Area

- 3.24 The main influence on the 2D domain extent is generally the expected width of the floodplain, meaning that it should be large enough to allow for flows to be routed through the floodplain, where necessary, and so that no “glass walling” occurs within the boundary of the model domain.
- 3.25 The river channel was deactivated to ensure that it was modelled in the 1D domain. This deactivated area may appear fragmented in places where the deck of a structure is modelled in the 2D domain. The active area is displayed in **Figure 3.1** and is shown in the Model Schematic included as **Appendix 4**.

Grid Size and Orientation

- 3.26 The grid cell size should be chosen in order to sufficiently represent the average width of the modelled channel and its ability to capture key floodplain topographic features.
- 3.27 The selected grid size of 2m provides a high enough resolution to capture the capacity of the channel (6m width = 3 number of 2m cells) as well as provide the representation of key floodplain features to an appropriate level of detail.

- 3.28 The orientation of the grid is important for flow routing as flow cannot pass to the neighbouring cell via its corner, only via the cell sides. Therefore, the location line (2d_loc) was drawn to orientate the grid in the predominant direction of flow (southeast to northwest).

Floodplain Roughness

- 3.29 Floodplain roughness is defined by the Manning's n coefficient, as per the 1D domain. However, the method in which it is applied differs.
- 3.30 A global roughness value is set based on the predominant land use (long grass) in the catchment. This is then supplemented by a series of polygons, based on spatial variation in land use, which applies values, where appropriate, from a variety of sources such as OS MasterMap data and aerial imagery. These are linked to a coefficient listed in a TUFLOW Materials File (TMF).
- 3.31 The values applied for different land use types are listed in **Table 3.2**.

Table 3.2: Floodplain Roughness Values

Land Use Type	Manning's n Coefficient
Long grass	0.035
Short grass	0.030
Roads	0.015
Woodland	0.060
Buildings	0.500

Floodplain Topography and Amendments

- 3.32 The general floodplain topography is based on the latest available LiDAR data (flown in 2020), which was downloaded from the DEFRA Open Survey website at a 1m resolution.
- 3.33 The following amendments to the base topography were made:
- River bank levels were reinforced through the use of a 'THICK' z-line. Bank elevations were provided at intervals along the z-line. The levels were informed by surveyed cross section data, topographical survey and LiDAR data (where survey data was unavailable).
 - Stoke Road was reinforced through the use of a z-shape. Road elevations were provided at intervals along the z-shape. The levels were informed by topographical survey and LiDAR (where survey was unavailable).
 - Approximately 400m of the eastern UOW was reinforced upstream of Nelson Drive through using a z-shape, with a width of 3, given that no watercourse survey data was available. The bed level of the UOW was reinforced from LiDAR at intervals

along the z-shape. Spot checks were then undertaken on the model grid to ensure a constant positive gradient towards the 1D domain.

Floodplain Structures

- 3.34 There were no floodplain structures within the model. All hydraulic structures were in line with the channel and hence modelled in the 1D domain.

Boundary Conditions

- 3.35 Boundary conditions within the 2D domain are often used to prevent “glass walling” at the downstream end of the model through use of a “HQ” boundary. This is a flow vs stage relationship automatically defined in TUFLOW when the user inputs a slope value, to allow water to flow out of the model.
- 3.36 A “HQ” boundary was applied to the downstream extent of the model and adjacent to any sewers located near to the 2D domain. The slope in the “HQ” boundary was calculated by assessing the fall in floodplain ground levels over a set distance. The fall in ground levels was then divided by the distance measured to determine a slope value.

Initial Water Levels

- 3.37 Initial water levels are often applied to features such as lakes, ponds or canals to represent them containing water of a nominal depth at the start of the model run.
- 3.38 An initial water level was applied at each cross section. The value was taken from the surveyed water level.

Calibration/Verification

- 3.39 A lack of detailed flow or level data for the catchment meant that there was limited opportunity to calibrate the model.
- 3.40 Due to the lack of documentation on previous historical instances of flooding, the model cannot be verified against historic events. A conservative approach adopted to the model build mitigates this.

Stability, Warnings and Messages

- 3.41 TUFLOW has a number of indicators available to assess the stability of a model. These differ slightly between the Classic and HPC solver (the Classic solver was used for this model). The following indicators were checked to ensure the model was performing as expected:
- **Stage and flow time series** – A number of spot checks should be completed to ensure that conveyance through the channel is as expected and that both the stage and flow time series are reasonably smooth, particularly around the study area.

- **1D negative depths** – Significant negative depths indicate that instabilities are present.
- **Cumulative Mass Error** – A value of +/-1% is considered acceptable.
- **Velocities** – Unusually high velocities or circulating vectors are usually a sign of instabilities.

3.42 The time series graphs were reviewed along the modelled reaches and no significant issues were present that could compromise results at the site. The river channel water levels were shown to peak at approximately 6 hours into the event along the eastern UOW, 5 hours into the event along Reach 2 and 3.5hrs into the event along Reach 4.

3.43 No 1D or 2D negative depths were reported.

3.44 The baseline simulations reported a peak mass error within +/- 1% except for the very high magnitude events for the western ditches. The maximum peak mass error found within the model simulations was -1.05% for the 1 in 100-year +51%CC event. This occurs approximately 3-5 hours after the peak of the flood event and the mass error drops back into the accepted range within 15 mins of reaching this peak value. It should be noted that in both design events (1 in 100-year +22%CC) the mass error peaked within +/- 1%. Therefore, although not ideal, this mass error can be considered insignificant.

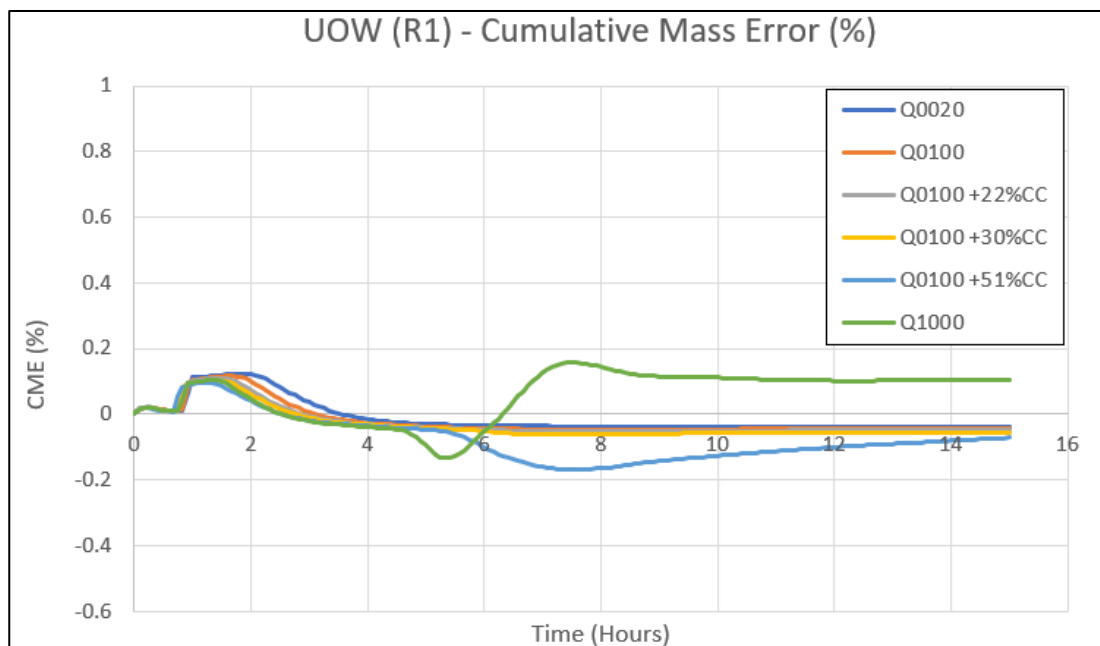


Figure 3.2: UOW (R1) Cumulative Mass Error Plots (Baseline)

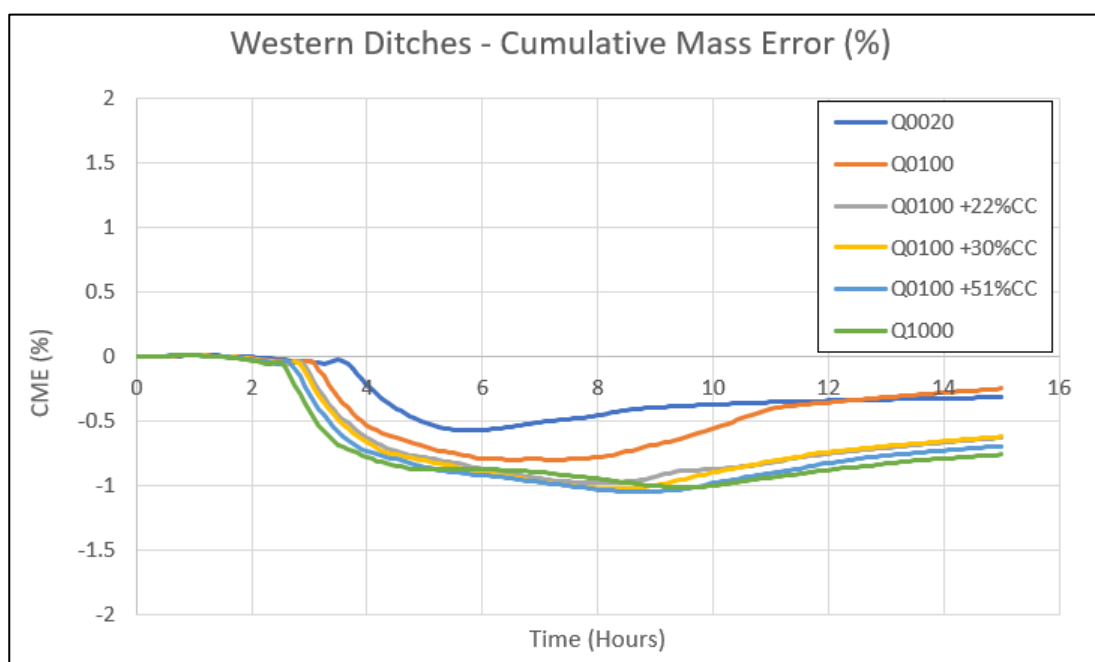


Figure 3.3: Western Ditches Cumulative Mass Error Plots (Baseline)

3.45 There were no warnings recorded during the simulation.

Model Runs

3.46 In order to achieve the study objectives, the simulations summarised in **Table 3.3** were completed.

Table 3.3: Model Runs

Model Scenario	Return Periods	Comments
Baseline Runs		
Baseline	1 in 20-Year 1 in 100-Year 1 in 1000-Year 1 in 100-Year +22%CC 1 in 100-Year +30%CC 1 in 100-Year +51%CC	Representative of 'as surveyed' conditions
Roughness +20%	1 in 100-Year	Floodplain, channel and structure roughness increased by 20%
Roughness -20%	1 in 100-Year	Floodplain, channel and structure roughness decreased by 20%
Downstream Boundary +	1 in 100-Year	Downstream boundary water level decreased by 100mm and 20% increase of gradient at HQ boundaries

Model Scenario	Return Periods	Comments
Downstream Boundary -	1 in 100-Year	Downstream boundary water level increased by 100mm and 20% decrease of gradient at HQ boundaries
Proposed Runs		
Proposed Design	1 in 20-Year 1 in 100-Year 1 in 100-Year +22%CC	Representative of 'post-development' conditions including the proposed watercourse diversion scheme
Blockage 1 (UOW001_01475)	1 in 100-Year	75% blockage of each opening
Blockage 2 (Representation of sewer network at locations 1B, 2B and 3D)	1 in 100-Year	75% blockage of three trunk sewers
Blockage 3 (R2_00071_PRO)	1 in 100-Year	75% blockage of proposed culvert
Blockage 4 (R4_00000)	1 in 100-Year	75% blockage

4. BASELINE RESULTS

- 4.1 The baseline floodplain extents are provided in **Appendix 5** and are summarised below.

UOW (R1)

- 4.2 The floodplain extents and levels at selected locations for the UOW (R1) are illustrated in **Figure 4.1** and **Table 4.1**.

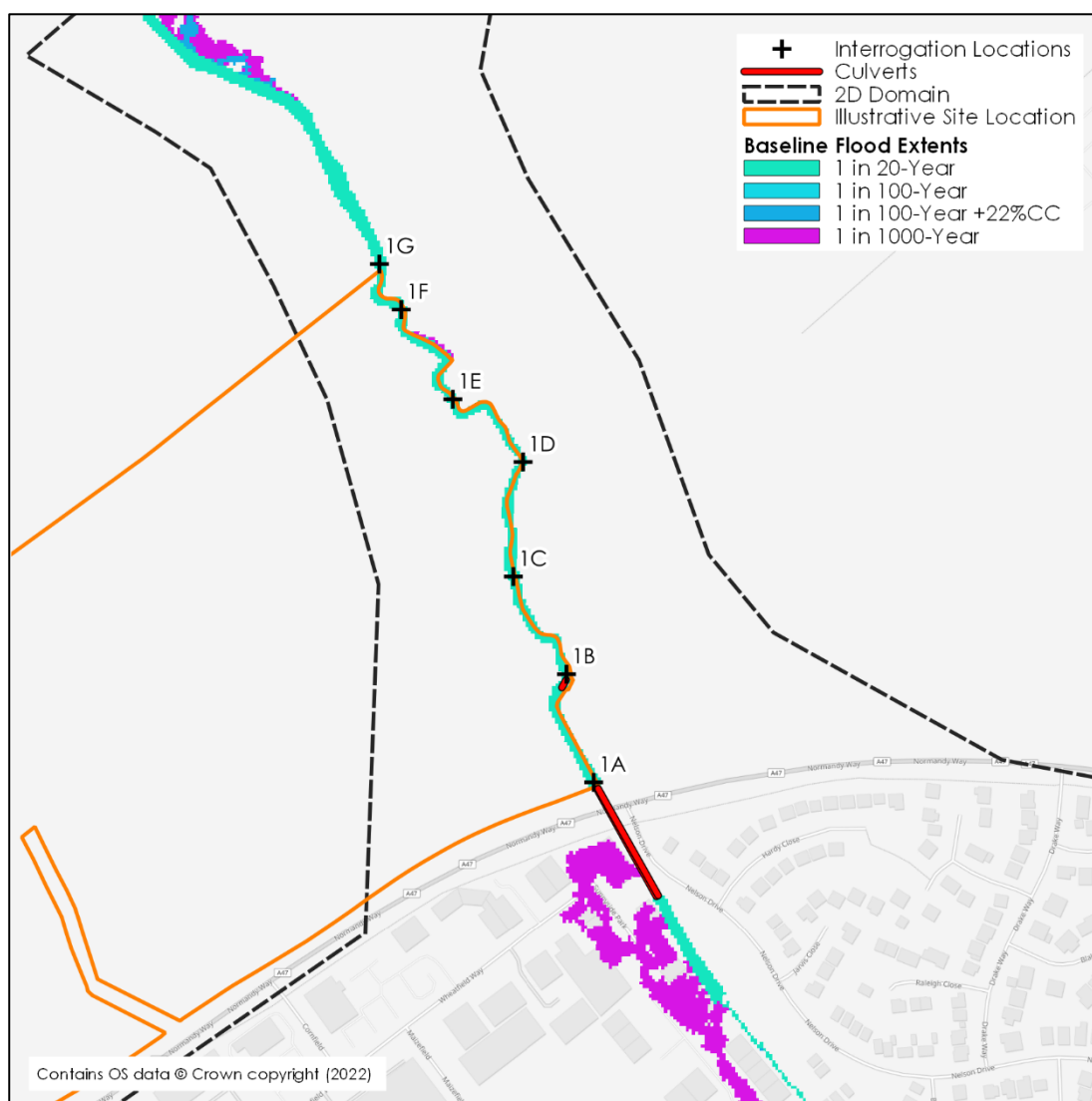


Figure 4.1: UOW (R1) Flood Extents

Table 4.1: UOW (R1) Peak Flood Levels (mAOD)

ID	1 in 20-Year	1 in 100-Year	1 in 100-Year + 22%CC	1 in 1000-Year
1A	108.12	108.20	108.26	108.43

1B	107.23	107.41	107.51	107.73
1C	107.08	107.25	107.34	107.55
1D	106.84	107.00	107.08	107.27
1E	106.51	106.66	106.73	106.91
1F	106.12	106.28	106.35	106.51
1G	105.97	106.10	106.15	106.27

Flood Mechanisms

- 4.3 The flood mechanisms for the UOW (R1) are shown in **Figure 4.2** and are summarised below.

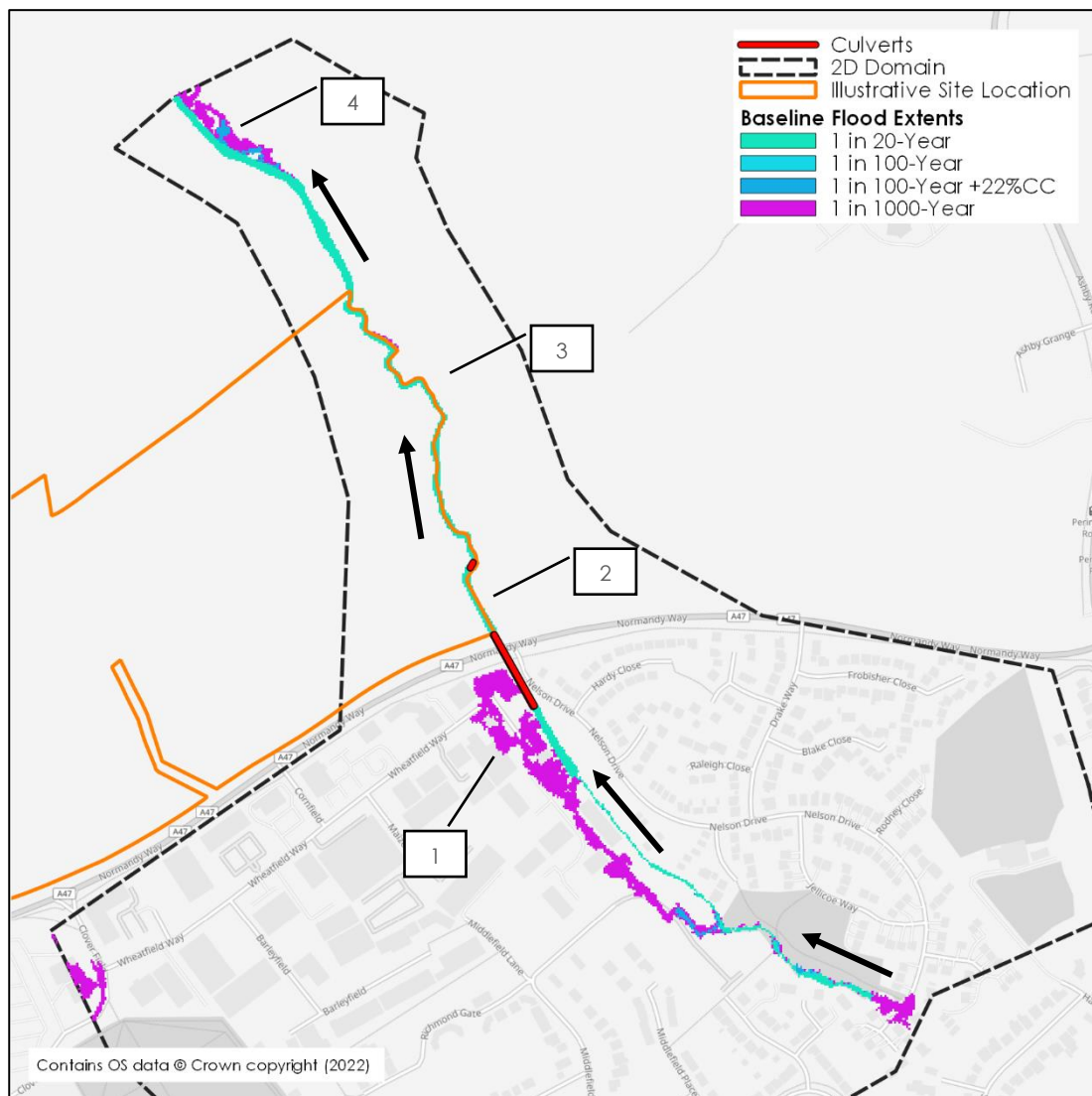


Figure 4.2: UOW (R1) Flood Mechanisms

1 – The UOW enters the site via twin 0.5m diameter culverts beneath Normandy Way. The structure is shown to have insufficient capacity to convey peak flows during the 1 in 1000-year event. Subsequently, the pipe becomes surcharged, resulting in localised flooding predicted immediately upstream.

2 – There are notable differences between the modelled 1 in 1000-year flood extent and the 1 in 1000-year surface water (low risk scenario) extent (see **Figure 1.6**). The surface water mapping does not explicitly represent culverts and structures and therefore is expected to provide a conservative representation of surface water flood risk at the site. The hydraulic model has represented the culvert (2 x 0.5m diameter pipes) beneath Normandy Way which has sufficient capacity to convey flows through the site for events up to the 1 in 1000-year. Subsequently, there is a reduction in flood extent when compared to the surface water mapping.

3 – As the UOW flows adjacent to the site, maximum water levels remain in-channel. Subsequently, the proposed residential development is located outside of all modelled flood extents from this watercourse.

4 – Downstream of the site, flood events in excess of the 1 in 100-year event are predicted to exceed the channel capacity, with evidence of overtopping along the right bank.

Western Ditches (R2, R3 and R4)

- 4.4 The floodplain extents and levels at selected locations for the western ditches (R2, R3 and R4) are illustrated in **Figure 4.3** and **Table 4.2**.

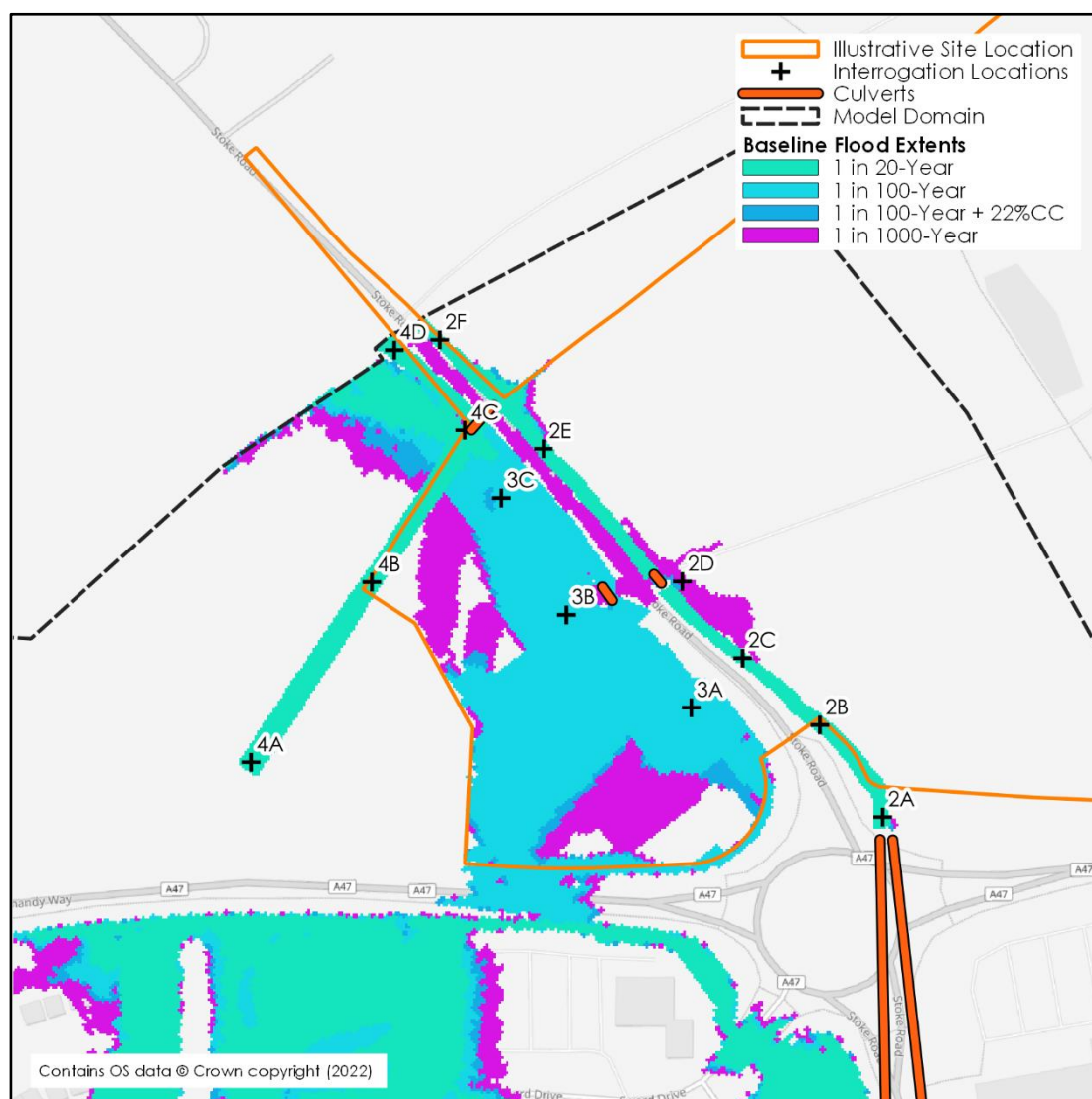


Figure 4.3: Western Ditches (R2, R3 and R4) Flood Extents

Table 4.2: Western Ditches (R2, R3 and R4) Peak Flood Levels (mAOD)

ID	1 in 20-Year	1 in 100-Year	1 in 100-Year + 22%CC	1 in 1000-Year
2A	105.71	105.81	105.89	106.00
2B	105.48	105.65	105.78	105.88
2C	105.36	105.58	105.72	105.80
2D	-	-	-	105.74
2E	104.57	104.63	104.67	104.75
2F	104.01	104.02	104.03	104.04
3A	-	105.39	105.39	105.40

3B	-	105.11	105.12	105.13
3C	-	104.72	104.73	104.75
4A	104.57	104.62	104.66	104.75
4B	104.54	104.58	104.60	104.66
4C	104.54	104.57	104.59	104.64
4D	104.09	104.11	104.12	104.12

Flood Mechanisms

- 4.5 The flood mechanisms for the western ditches (R2, R3 and R4) are shown in **Figure 4.4** and are summarised below.

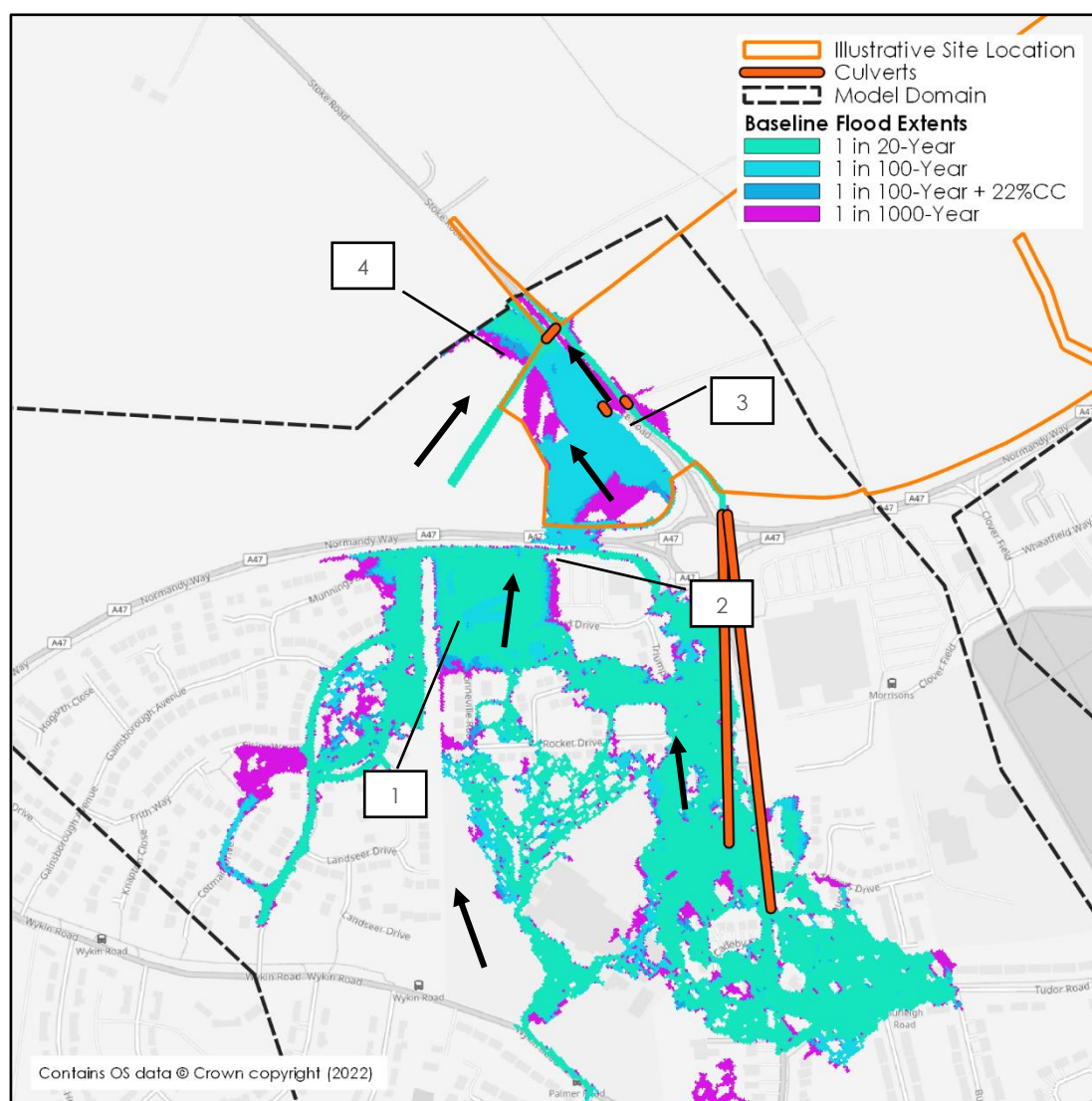


Figure 4.4: Western Ditches (R2, R3, R4) Flood Mechanisms

1 – The manholes represented within the upstream Severn Trent sewer network are predicted to surcharge during all events including the 1 in 20-year event. This subsequently results in out of bank flooding predicted upstream of Normandy Way for all modelled return periods. This aligns with known capacity issues in this area that have been raised by Severn Trent Water at the time of consultation.

2 – As a consequence of flood waters accumulating upstream of Normandy Way, the model predicts that the A47 will be overtopped during the 1 in 100-year return period and larger magnitude events. It is subsequently predicted that flood waters will be conveyed into the land parcel west of Stoke Road.

3 – During the 1 in 1000-year event, out of bank flooding is predicted at low levels of the eastern land parcel immediately adjacent to R2. This occurs due to the 600mm diameter culvert having insufficient capacity to convey peak flows for the 1 in 1000-year event without the right bank being overtopped. Ground levels on this bank are lower due to an incoming hedgerow with an associated drainage ditch.

4 - Flows also exceed channel capacity where R4 is assumed to converge with R2. This is understood to be associated with a restrictive irregular culvert and a topographical depression adjacent to the road between R3 and R4, which overland flows subsequently pool within.

5. PROPOSED DEVELOPMENT MODELLING

Philosophy

- 5.1 A new roundabout is proposed along Stoke Road in order to provide access to the proposed development. The proposed roundabout and associated access road into the site is shown to cross existing ditches that convey flows adjacent to Stoke Road.
- 5.2 As such, it is proposed to divert and culvert R2 around the roundabout and underneath the proposed access road within the site. It is proposed that R3 will also be diverted around the proposed roundabout and will discharge into R4.
- 5.3 This diversion scheme has been proposed to limit the extent of culverting beneath the proposed roundabout and to promote the daylighting of the watercourse.
- 5.4 No changes were made to the UOW (R1), which forms the eastern boundary of the proposed development.
- 5.5 A model schematic is included as **Appendix 6**.

Representation in Hydraulic Model

- 5.6 The baseline model was updated as follows:
 - R2 was diverted around the proposed roundabout within the site. The cross sections were amended to be 3m wide in total with a 0.8m width bed, 1:1 bank slopes and a gradient of 1:350.
 - A proposed box culvert (0.8m x 0.5m) was added to R2, allowing flows to pass beneath the proposed access road. The soffit level of the opening was set to 104.55mAOD, allowing for 0.95m of cover from the deck of the proposed access road. At this outline stage, the proposed road level of 105.50mAOD has been derived from the existing topographical survey in the absence of design levels. This is considered a conservative approach as it is anticipated that ground levels will be raised in the construction of the new access road and a larger culvert could be used. However, this initial representation of the culvert structure allows for an assessment of flood risk from the proposed design concept within the hydraulic model and to identify potential impacts to third party land. A schematic showing the proposed culvert is presented in **Figure 5.1**.
 - R3 was diverted around the southwestern perimeter of the proposed roundabout and outfalls into R4. The cross sections were also amended to be 3m wide in total with a 0.8m width bed, 1:1 bank slopes and a gradient of 1:350. Due to the proposed levels and contributing catchment, it was deemed acceptable to outfall the diverted R3 into R4.

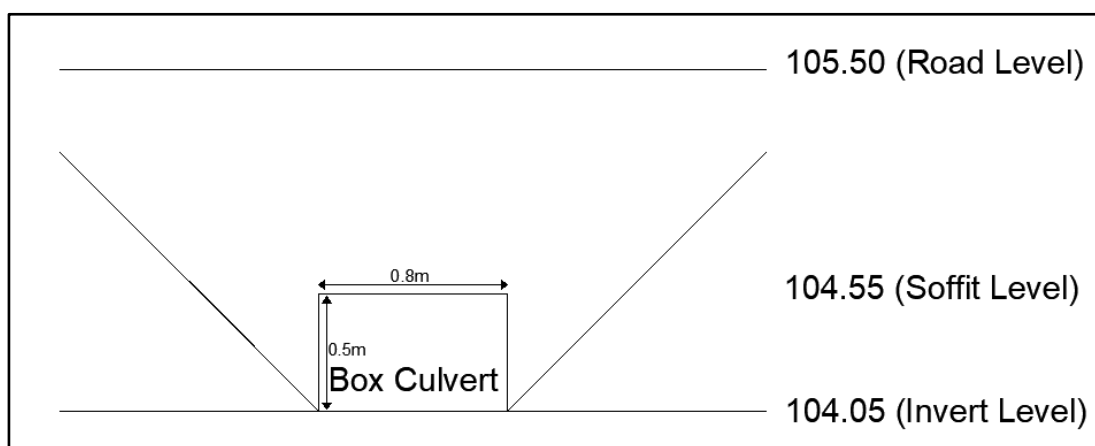


Figure 5.1: Modelled Schematic of Culvert Beneath Proposed Access Road

- 5.7 The model was simulated for the 20-year, 100-year and 100-year + 22% climate change events.

Model Results

- 5.8 The proposed development model results are included in **Figure 5.2** and **Appendix 7**.
- 5.9 The modelled flood levels are summarised in **Table 5.1**.

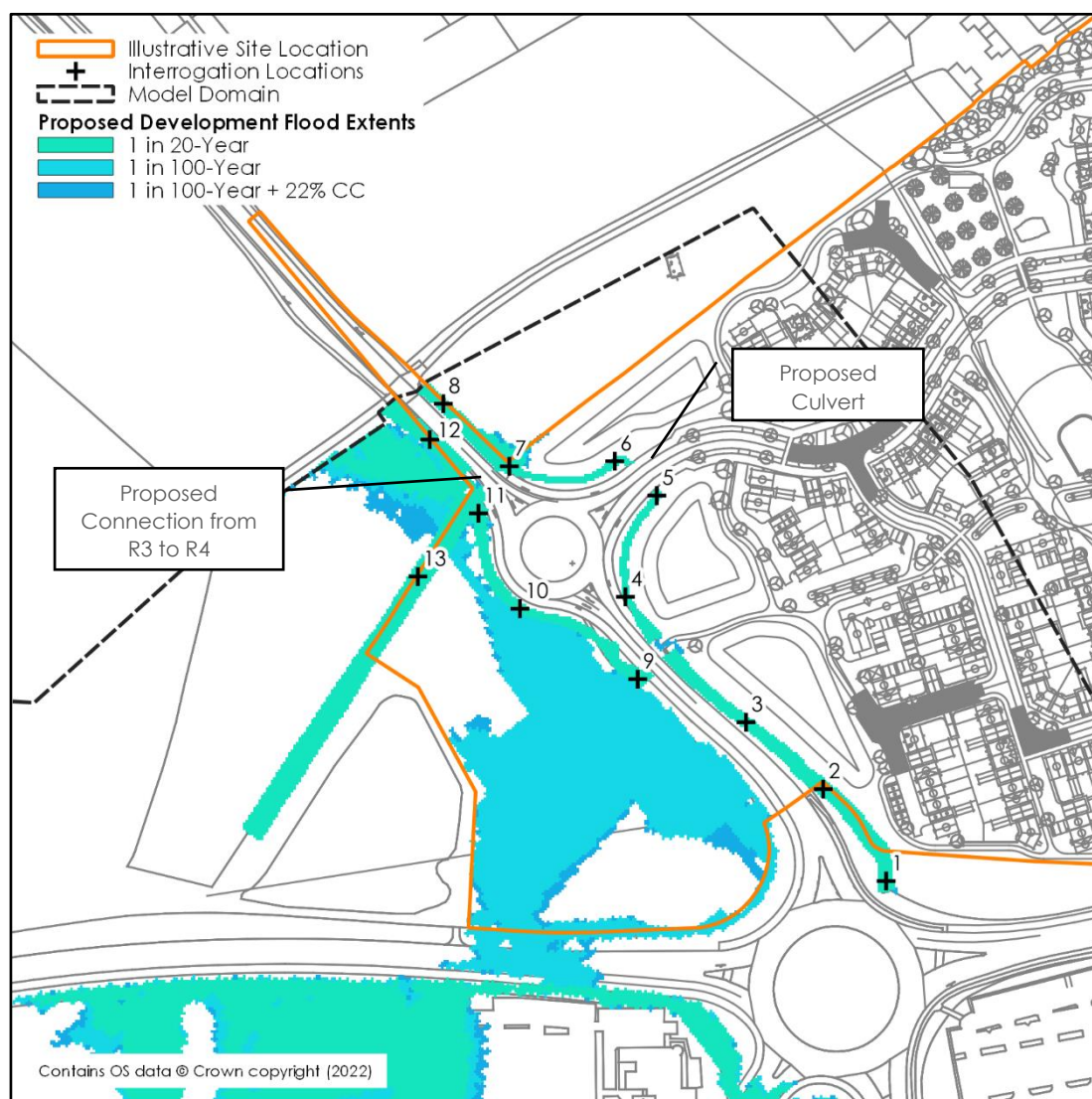


Figure 5.2: Proposed Development Floodplain Extents

Table 5.1: Proposed Development Peak Flood Levels (mAOD)

ID	1 in 20-Year	1 in 100-Year	1 in 100-Year + 22%CC
1	105.71	105.81	105.89
2	105.48	105.65	105.78
3	105.36	105.58	105.72
4	104.78	104.92	105.04
5	104.67	104.86	104.99
6	104.56	104.63	104.67
7	104.49	104.54	104.57
8	104.01	104.02	104.03

ID	1 in 20-Year	1 in 100-Year	1 in 100-Year + 22%CC
9	104.52	104.57	104.61
10	104.52	104.57	104.59
11	104.52	104.57	104.59
12	104.28	104.31	104.32
13	104.52	104.57	104.59

Impact Analysis

- 5.10 The proposed development modelled peak flood levels have been compared to the equivalent baseline peak flood levels to establish off site impacts.
- 5.11 Based on the latest EA guidance, this has been assessed for events up to the 1 in 100-year + 22% climate change allowance event.
- 5.12 Impact analysis mapping is included in **Appendix 7**.
- 5.13 In the proposed modelling scenario, water is routed through the diverted channels. The proposed culvert underneath the access road and the proposed channel is shown to have sufficient capacity to convey flows for all events up and including to the 1 in 100-year + 22% climate change event. The roundabout is shown to be unaffected during all events up to and including the 1 in 100-year + 22% climate change event.
- 5.14 There is a minor decrease in peak flood levels to the east of R2, adjacent to the proposed development. For the majority of this reach there are no changes to peak flood levels as a result of the proposed diversion scheme.
- 5.15 The diversion of R3 is largely shown to result in no changes to peak flood levels, however, there is a decrease in flood levels where there have been topographic changes to divert the channel. As a direct consequence of this, there is subsequently a minor increase in flood levels adjacent to the channel, however these are confined to the immediate vicinity of the channel.

6. SENSITIVITY TESTING

- 6.1 To account for seasonal variations in vegetation and to ensure the robustness of boundary conditions, a series of sensitivity tests were conducted using the 1 in 100-year flood return period event. The difference in peak water level and floodplain extent between the sensitivity test scenarios and the 1 in 100-year baseline event are mapped in **Appendix 8**.
- 6.2 Robust sensitivity analysis also provides improved confidence in the model outputs, particularly in absence of calibration data.

Downstream Boundary

- 6.3 The modelled 1D downstream boundary is a HT boundary set in accordance with the top of bank or water level at the time of survey. The boundary was adjusted by 100mm within the sensitivity tests. The 2D HQ boundary slopes were also updated by 20%. These sensitivity tests were applied to the Baseline Scenario.
- 6.4 A 100mm increase in the HT boundary level and an increase in the slope gradient (20%) at the HQ boundaries leads to a decrease in peak flood level towards the downstream boundary of the UOW (R1). There is no change in peak flood levels or flood extents adjacent to the site. There are localised changes in peak flood level along the western ditches and a small, localised increase in modelled flood extent. The depths within the site boundary are shown to increase by 60mm in this area, as shown in **Appendix 8**.
- 6.5 A 100mm decrease in the HT boundary level and a reduction in the slope gradient (20%) at the HQ boundaries leads to an increase in peak flood level towards the downstream boundary of the UOW (R1). There is no change in peak flood levels or flood extents adjacent to the site. There are localised changes in peak flood level along the western ditches and a small, localised decrease in modelled flood extent. The depths within the site boundary are shown to decrease by 90mm in this area, as shown in **Appendix 8**.
- 6.6 Although there are differences in peak levels towards the downstream boundary, these effects do not propagate a significant distance upstream towards the site. This therefore indicates that the model results are not sensitive to changes to the downstream boundary.

Roughness Coefficients

- 6.7 The modelled roughness coefficients were determined from aerial imagery and site photographs. Increasing and decreasing the roughness values in the channel and structures as well as on the floodplain will test how seasonal variation and maintenance regimes may affect the flood risk posed to the development. These sensitivity tests were applied to the Baseline Scenario.
- 6.8 A 20% increase in Manning's n roughness coefficient, representative of a period without maintenance, leads to increased peak flood levels and floodplain extents

across the model domain. Adjacent to the site, peak flood levels are expected to increase by up to 90mm when compared to the baseline results.

- 6.9 This is to be expected given that an increase in roughness values across the floodplain will be associated with greater frictional forces against the flow of water. Subsequently, more flood water would likely be retained on the floodplain during these conditions, therefore resulting in a general increase in flood levels. Similarly, greater in-channel Manning's values would be expected to increase water levels as a rougher channel would detrimentally impact flows.
- 6.10 A 20% decrease in Manning's n roughness coefficient, representative of a period with maintenance, leads to reduced peak flood levels and floodplain extents across the model domain. Adjacent to the site, peak flood levels are shown to decrease by up to 100mm when compared to the baseline results.
- 6.11 This is to be expected, as the reduced roughness will increase the conveyance of the floodplain and culverts, allowing water to flow more freely through the system.

Blockage Scenarios

- 6.12 Blockage testing was applied at four locations. For each blockage scenario, a 75% blockage was applied. All simulations were run for the proposed scenario given the need to understand the impacts of blocking key proposed structures as part of the watercourse diversion scheme. The locations of the blockages are annotated on the respective mapping, provided in **Appendix 8**.

UOW (R1)

- 6.13 A blockage scenario was tested within the hydraulic model on the twin culverts underneath Normandy Way on the UOW (R1). Each opening is approximately 0.5m in width and therefore a 75% blockage was applied to each of the openings, which is considered appropriate due to their size. The flood levels around the culverts and upstream of the culverts are predicted to increase by up to 1.2m which results in a localised increase in flood extents adjacent to the culverts. Flood levels downstream of the culvert, adjacent to the site are shown to decrease by up to 0.03m.

Western Ditches (R2, R3 and R4)

- 6.14 The sewer network upstream of the western ditches is shown to be a key flood mechanism, as flows exceed the capacity of the sewer network, overtop Normandy Way and flow into the site. Therefore, a blockage scenario was also tested on the sewer network. A 75% blockage was applied to three trunk sewers at locations where flows are shown to exceed the network. There are localised increases to peak flood levels by up to 0.03m in close proximity to the sewer network with minor increases in flood extents. Flood levels within R2 are shown to decrease. The majority of the model domain shows no change to peak flood levels.
- 6.15 A blockage scenario was also tested on the proposed culvert underneath the proposed access road. A 75% blockage was applied to the cross-sectional area, which

is considered appropriate due to the size of the culvert. The flood levels around the culvert and upstream of the culvert are predicted to increase by up to 0.68m which results in an increase in flood extents. Water is shown to overtop the proposed roundabout and access road which results in a localised increase in peak flood levels adjacent to R3. Minor decreases in flood levels downstream of the culvert (approx. 0.02m) are predicted in this scenario.

- 6.16 A final blockage scenario was tested on the existing culvert underneath Stoke Road which connects R4 to R2. A 75% blockage was applied to the opening, which is considered appropriate due to the site of the culvert. The flood levels around and upstream of the culvert are predicted to increase by up to 0.02m which results in an increase in flood extents. Minor decreases in flood levels downstream of the culvert (approx. 0.06m) are predicted in this scenario.
- 6.17 While the blockage scenarios are shown to result in localised increases in peak flood levels near the site, this does not result in increased flood risk to the residential development. As the proposed roundabout and access road are shown to be affected by the blockage of the proposed culvert, hazard mapping has been produced for this scenario and is included as **Appendix 8**. The hazard mapping shows that the proposed access road and roundabout is at a 'Low' hazard rating (<0.75).

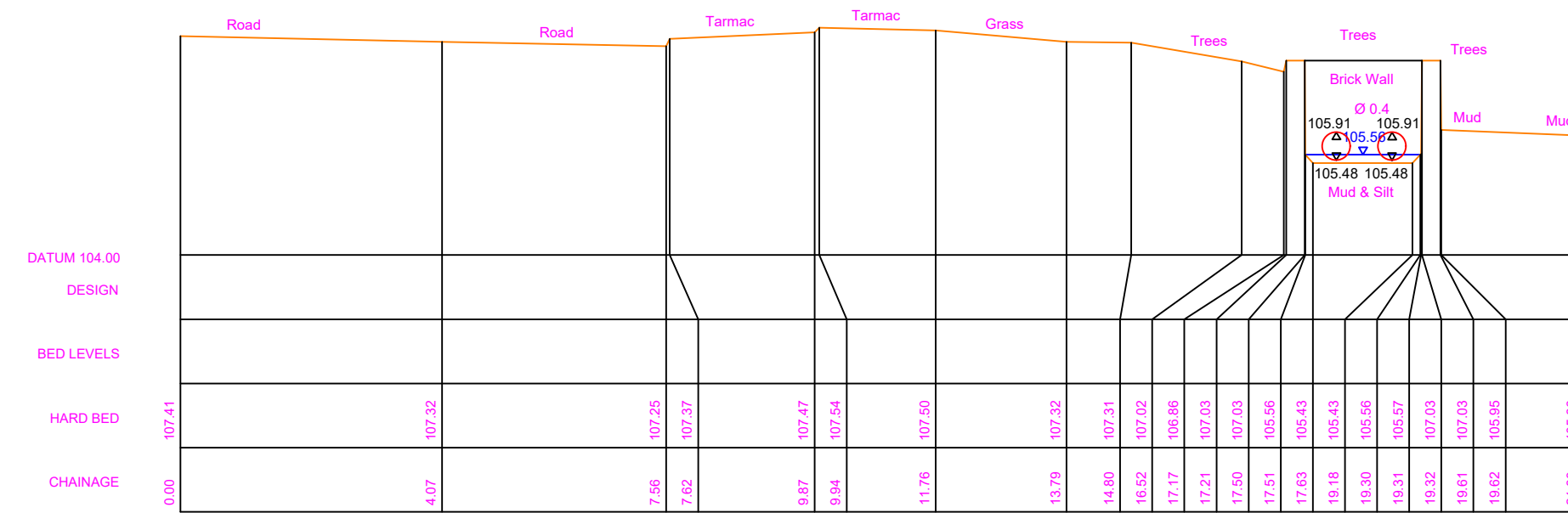
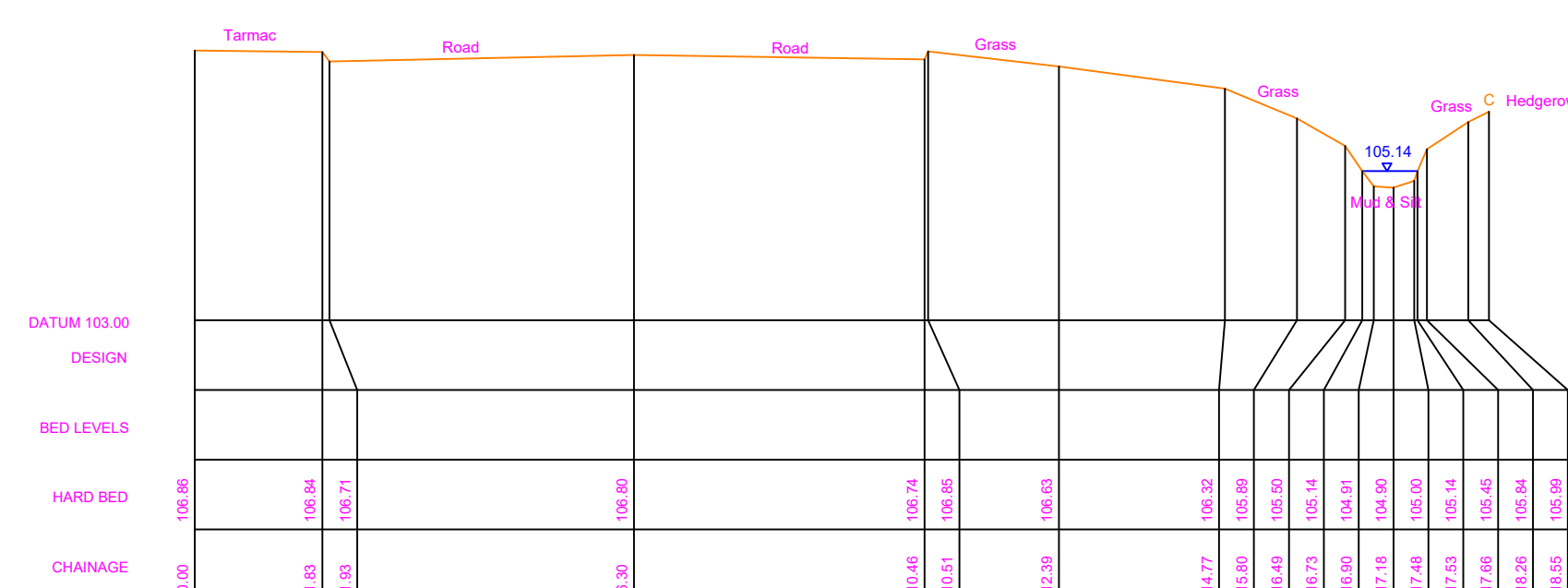
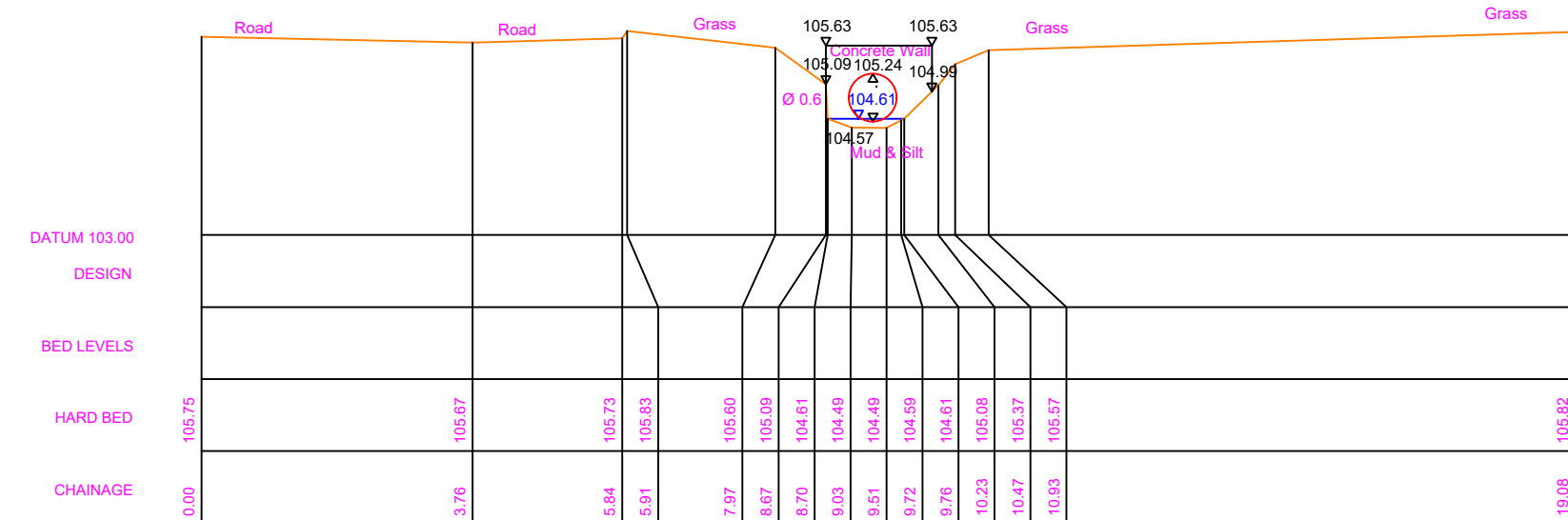
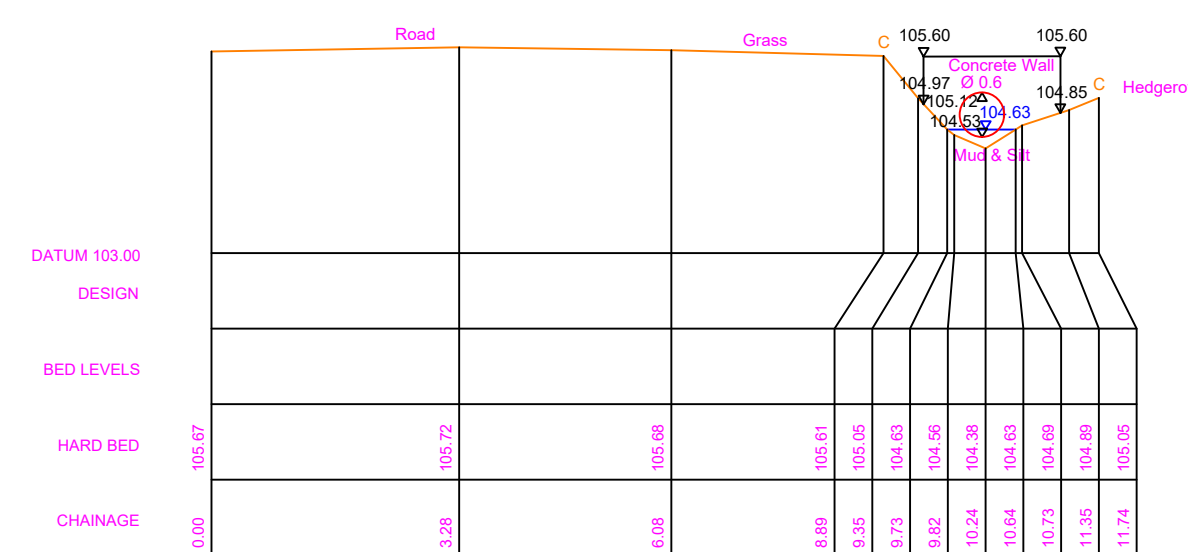
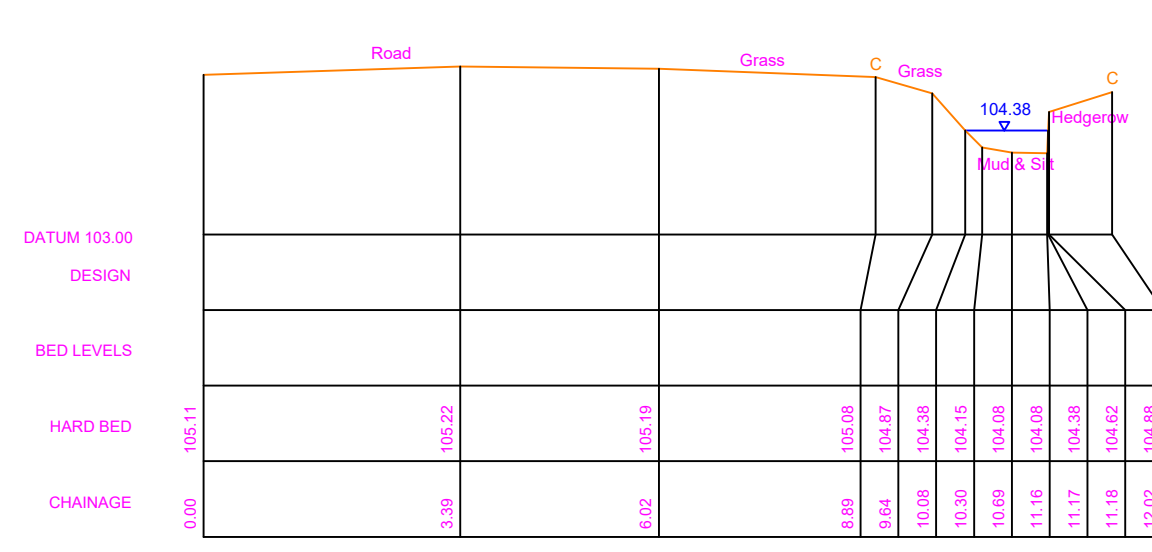
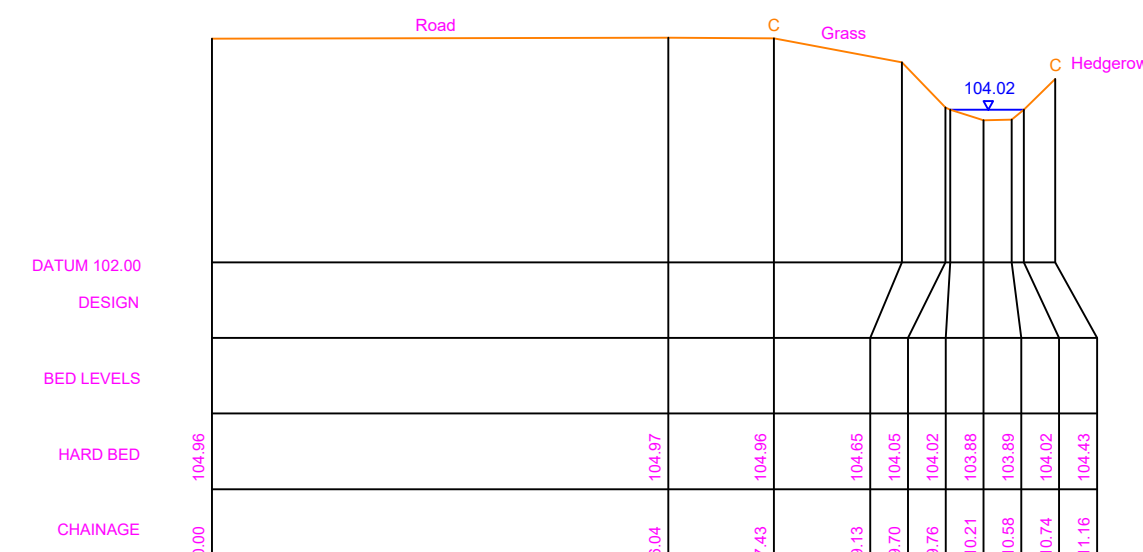
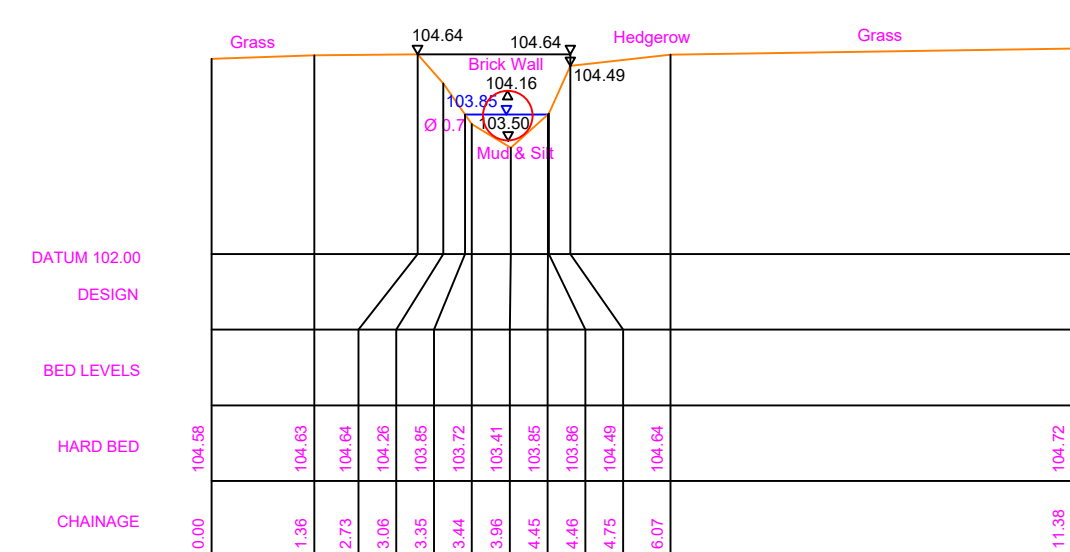
7. SUMMARY & RECOMMENDATIONS

- 7.1 Please note that this conclusion should be read in conjunction with the study limitations and assumptions in **Section 1**.
- 7.2 BWB Consulting Ltd has been commissioned by Richborough Estates Limited and Mr & Mrs Adcock to undertake a site-specific hydraulic modelling exercise of an Unnamed Ordinary Watercourse (UOW) and a series of ditches to support a residential development to the North of Hinckley.
- 7.3 The modelled flood flows have been informed by a hydrological review of the catchment associated with the UOW (R1) and western ditches within the vicinity of the site. The latest climate change allowances have been incorporated into the hydrological assessment.
- 7.4 The baseline model results provide a representation of surface water sewers within the hydraulic model. By representing the capacity of the sewer network, greater confidence in flooding mechanisms can be taken from the outputs of the hydraulic modelling study than what is otherwise provided by existing datasets (such as the EA surface water mapping). The baseline results show the UOW (R1) to remain in channel for all events adjacent to the site.
- 7.5 Flows are predicted to exceed the capacity of the Severn Trent Water trunk sewers within the residential development south of the site, leading to the manholes surcharging and overland flow being directed to the west of the site. Within the western ditches, R2 is shown to overtop both banks adjacent to the access track on the eastern side of Stoke Road, this is due to a restrictive 600mm diameter culvert. Water also marginally overtops where R4 is assumed to converge with R2, which is associated with a restrictive irregular culvert and a topographical depression adjacent to the road which water pools within.
- 7.6 A new roundabout is proposed along Stoke Road in order to provide access to the proposed development. As such, it is proposed to divert and culvert R2 around the roundabout and underneath the proposed access road within the site. It is proposed that R3 will also be diverted around the proposed roundabout and will discharge into R4. The proposed culvert underneath the access road and the proposed channel is shown to have sufficient capacity to convey flows for all events up to and including the 1 in 100-year + 22% climate change event. The roundabout is shown to be unaffected during all events up to and including the 1 in 100-year + 22% climate change event.
- 7.7 Sensitivity testing demonstrates that a 20% increase and decrease in Manning's n roughness coefficient leads to increased and decreased peak flood level and floodplain extents respectively.
- 7.8 Blockages of culverts result in increased flood levels and increases in flood extents within the site and within the vicinity of the site. However, the increased flood levels and extents do not increase risk to the residential development as it remains outside of the floodplain in these scenarios.

- 7.9 Additional testing shows the model results are sensitive to changes in downstream boundary in the immediate vicinity of the boundaries. However, further upstream from this, at the site, there is no change in peak flood levels.
- 7.10 The sensitivity tests do not have implications for flood risk to the residential development, which has been raised above peak flood levels. The proposed roundabout and access road is at residual risk of flooding in a blockage scenario, however this results in a 'Low' hazard rating. Subsequently, it is considered that safe access and egress from the site can be maintained.

APPENDICES

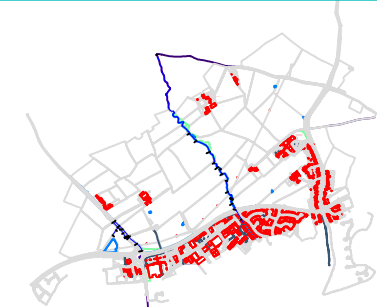
Appendix 1: River Channel Survey



- ### Note

1. Do not scale this drawing. All dimensions must be checked/ verified on site. If in doubt ask.
2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.
3. All dimensions in metres unless noted otherwise. All levels in metres unless noted otherwise.
4. Any discrepancies noted on site are to be reported to the engineer immediately.
5. No scale factor has been applied to this survey, therefore the co ordinates are to be treated as arbitrary. Please refer to survey station information below for on site control establishment.
6. All coordinates and height data relate to OSGB36(15). Control stations are coordinated by means of GPS receiving real time corrections via GPRS (not internet).
7. All manhole data is collected from ground level therefore discrepancies may occur. More accurate data is only achievable via confined space entry.
8. OS licence number: 100022432

Key Plan



Legend

- | | | | |
|--|--------------------|--|--|
| | OS Buildings | | Contour Lines |
| | Surveyed Buildings | | Inspection Chamber |
| | Buried | | Flow direction and pipe diameter |
| | Wall | | Station and Name |
| | Kerb Channel Line | | Monitoring Borehole |
| | Top Earth | | Trees / Bush / Sapling |
| | Edge of Surface | | Area of Vegetation / Extent of Tree Canopy |
| | Top of Bank | | Hedge |
| | Bottom of Bank | | Body of Water |
| | Canopy / Overhang | | Body of Water from OS |
| | Line Marking | | Spot Level |
| | Centre Line | | Assumed Surface |
| | Watercourse | | Water Drainage Line |
| | Centre Line | | Surface Water Drainage |
| | Barrier | | |
| | Fence | | |
| | Overhead Powerline | | |
| | Overhead Utilities | | |

- | | | | | | |
|-----|------------------|----------------------|----------------------|-----|------------------|
| AP | Ancher Plot | FBW | Fence Barbic Wire | LB | Litter Bin |
| AG | Buck Gully | FCB | Fence Closed Board | LP | Lamp Post |
| BO | Bollard | FCL | Fence Chain Link | MH | Manhole |
| BS | Bus Stop | FEL | Fence Electric | MZ | Service Marker |
| BT | Bus Stop Telecom | FM | Fence Metal Panel | MB | Mail Box |
| C | Cover | FMR | Fence Metal Railing | PT | Post |
| CL | Cover Level | FOB | Fence Open Board | RE | Reeding Eye |
| CMP | Gate Marker | FOW | Fence Post & Wire | SP | Sign Post |
| CS | Security Camera | FSP | Fence Steel Panels | ST | Stop Sign |
| CTV | Security Camera | FWM | Fence Wire Mesh | SV | Stop Valve |
| CTV | TV Camera | FFL | Finished Floor Level | TGB | Telephone |
| CD | Drainage | FP | Flagpole | CB | Call Box |
| CH | Channel | Gas | Gas | THL | Threshold Level |
| DK | Down Pipe | GL | Gully | TL | Traffic Light |
| DP | Down Pipe | GU | Gully | TP | Telegraph Post |
| Ele | Electric | H | Height | TS | Traffic Signal |
| EP | Electricity Post | IC | Interception Chamber | UTS | Unable to Survey |
| FL | Floodlight | IFL | In Flood Level | W | Water |
| FL | Fire Hydrant | IL | Invert Level | WM | Water Meter |
| FL | Floodlight | (as a reduced level) | | WO | Wash Out |

P1	09.02.22	First Issue	IR	DS
Rev	Date	Details of issue / revision	Draw	Re

Issues & Revision



Client

RICHBOROUGH ESTATES LTD

Project Title

HINCKLEY NORTH

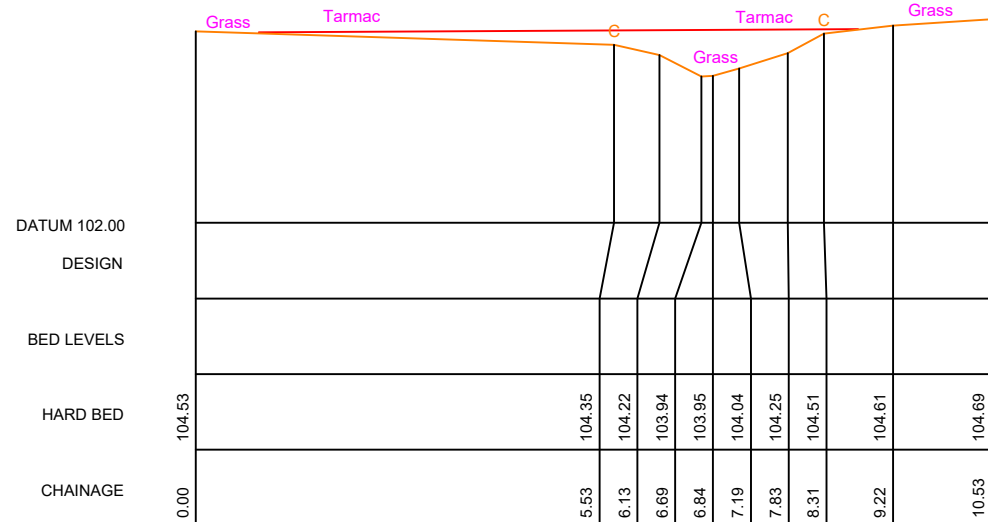
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**WATERCOURSE SURVEY
REACH 2
SHEET 2 OF 6**

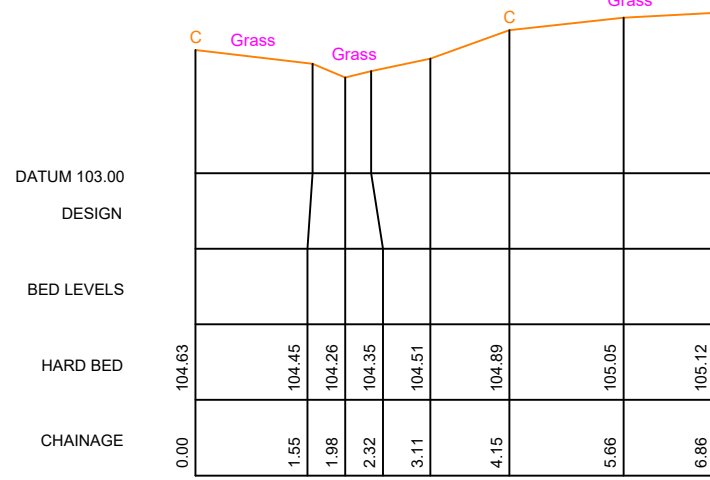
Drawn:	I.Riley	Reviewed:	D.Smith

Information

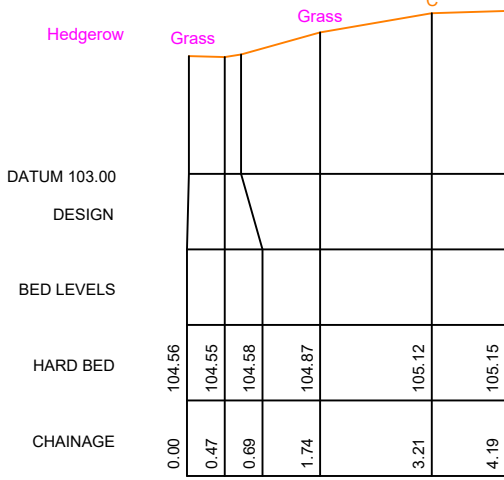
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HIN-BWB-02-ZZ-M2-G-0060	S2	P1



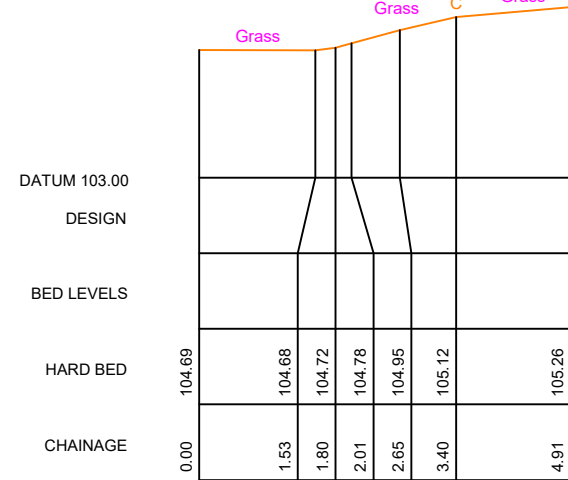
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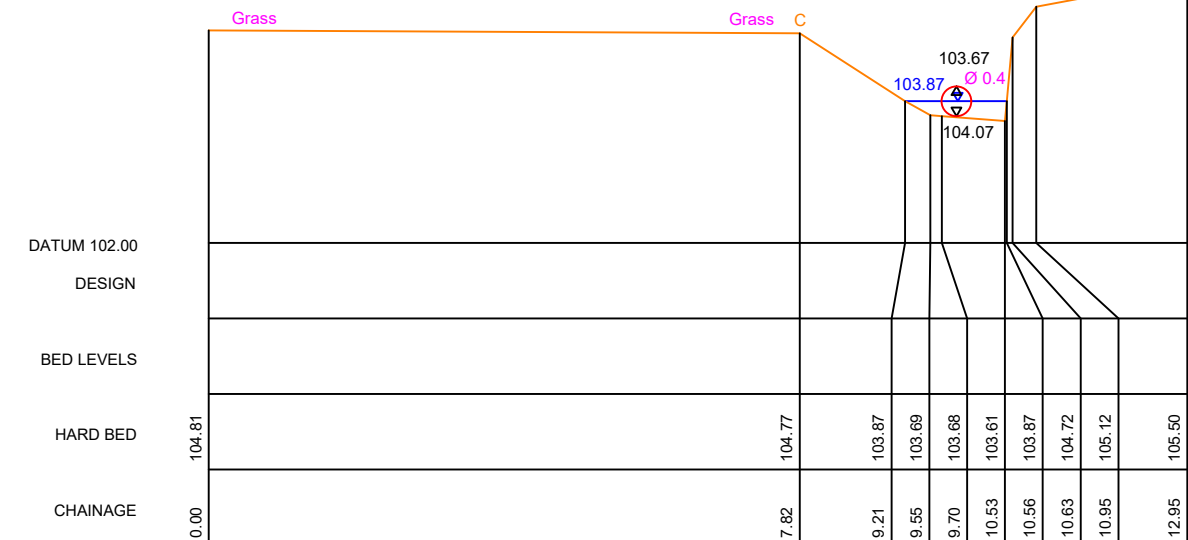
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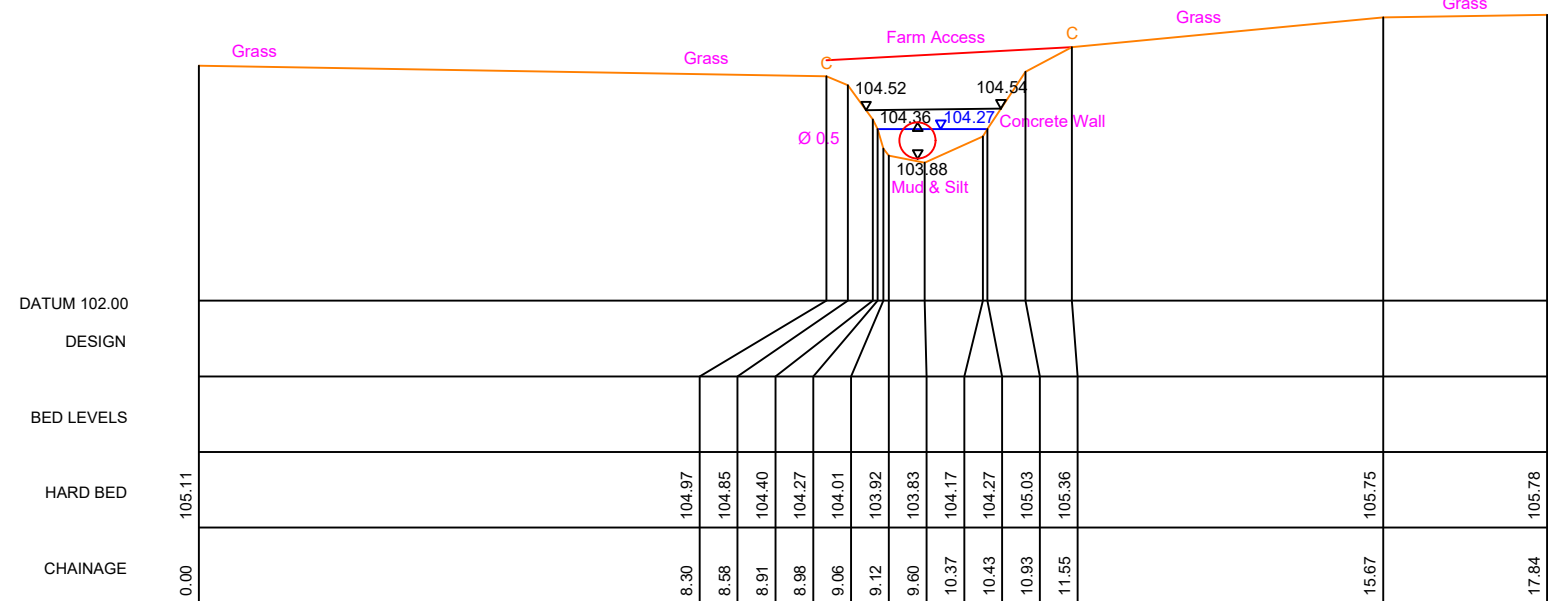
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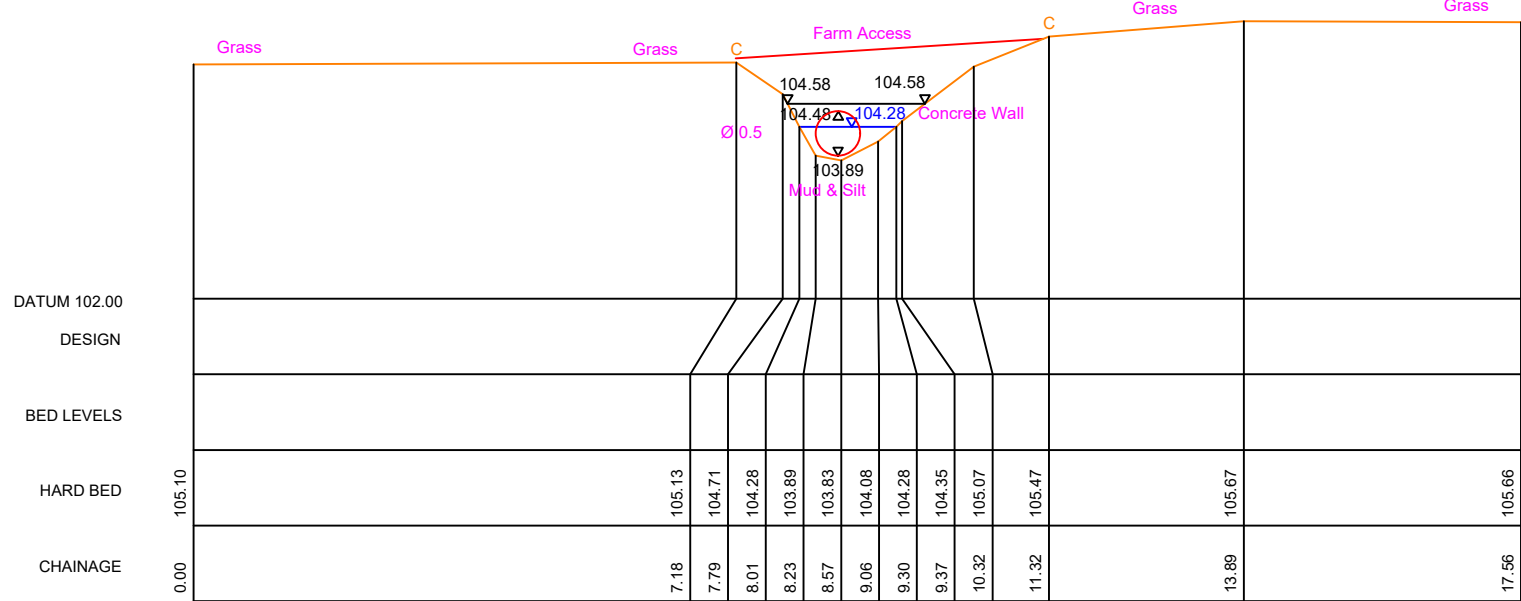
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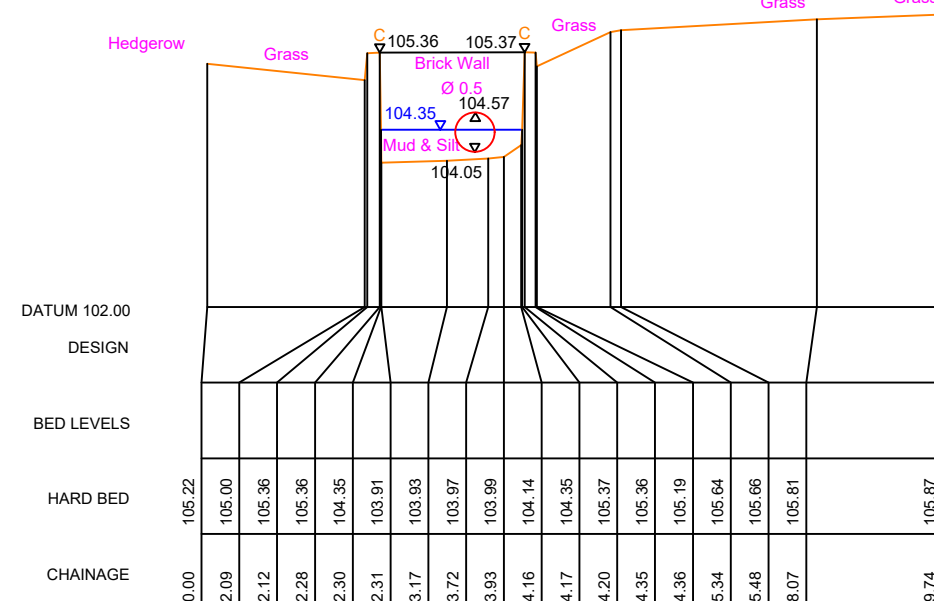
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Culvert



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Culvert

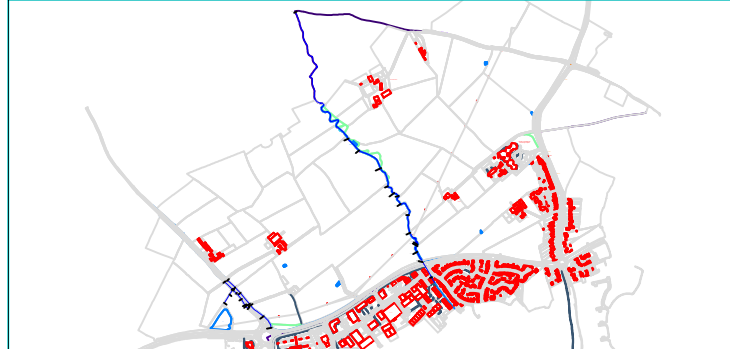


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Culvert

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- All coordinates and height data relate to OSGB36(15). Control stations are coordinated by means of GPS receiving real time corrections via OS smart net.
- All manhole data is collected from ground level therefore discrepancies may occur. More accurate data is only achievable via confined space entry.
- OS license number: 100022432

Key Plan



Legend

- OS Buildings
- Surveyed Buildings
- Building
- Wall
- Kerb Channel Line
- Edge of Kerb
- Top of Surface
- Bottom of Bank
- Canopy / Overhang
- Line Marking
- Centre Line
- Watercourse
- Centre Line
- Barrier
- Fence
- Gate
- Overhead Powerline
- Overhead Utilities
- Contour Lines
- Inspection Chamber
- Flow direction and pipe diameter
- Station and Name
- Monitoring Borehole
- Tree / Bush / Sapping
- Area of Vegetation/ Extant of Tree Canopy
- Hedge
- Body of Water
- Body of Water from OS
- Spot Level
- Assumed Surface
- Water Drainage Line
- Surface Water Drainage Line

- AP Anchor Point
- BO Back Gully
- BO Boltard
- BS Bus Stop
- BT British Telecom
- C Crest
- CL Cover Level
- CMP Cable Marker
- Pit
- CCTV/Security Camera
- CIV Cable TV
- DC Drainage
- DK Drain Kerb
- DP Down Pipe
- Elc Electric
- EP Electricity Post
- ER Earth Road
- FH Fire Hydrant
- FL Floodlight
- FBW Fence Barbed Wire
- FOB Fence Closed Board
- FCL Fence Chain Link
- FEL Fence Electric
- FMP Fence Metal Panel
- FMR Fence Metal Rolling
- FOB Fence Open Board
- FPW Fence Post & Wire
- FSP Fence Steel Pipeline
- FWM Fence Wire Mesh
- FYP Finished Floor Level
- Gas
- Gas Valve
- Gully
- Height
- IC Inspection Chamber
- ICL Internal Floor Level
- IL Invert Level
- LB Litter Bin
- LP Lamp Post
- MH Manhole
- MV Service Marker
- PS Post Box
- PT Post
- RE Roadside Eye
- SP Sign Post
- ST Stop Sign
- SV Stop Valve
- TCS Telephone
- Call Box
- Threshold Level
- TL Traffic Light
- TP Telegraph Post
- TS Traffic Signal
- UTS Unable to Survey
- VL Water Level
- WM Water Meter
- WO Wash Out

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Rev	Date	Details of issue / revision	Dw	Rev

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HINCKLEY NORTH

Drawing Title
**WATERCOURSE SURVEY
REACH 3
SHEET 3 OF 6**

Drawn: L.Riley Reviewed: D.Smith

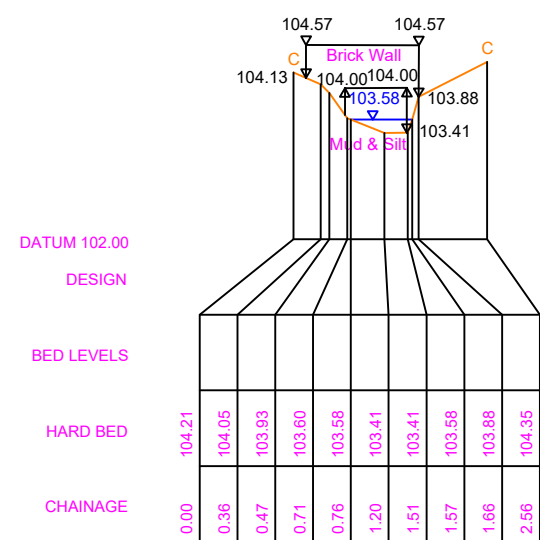
BWB Ref: 210683 Date: 09.02.22 Scale@A0: 1:100

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Information

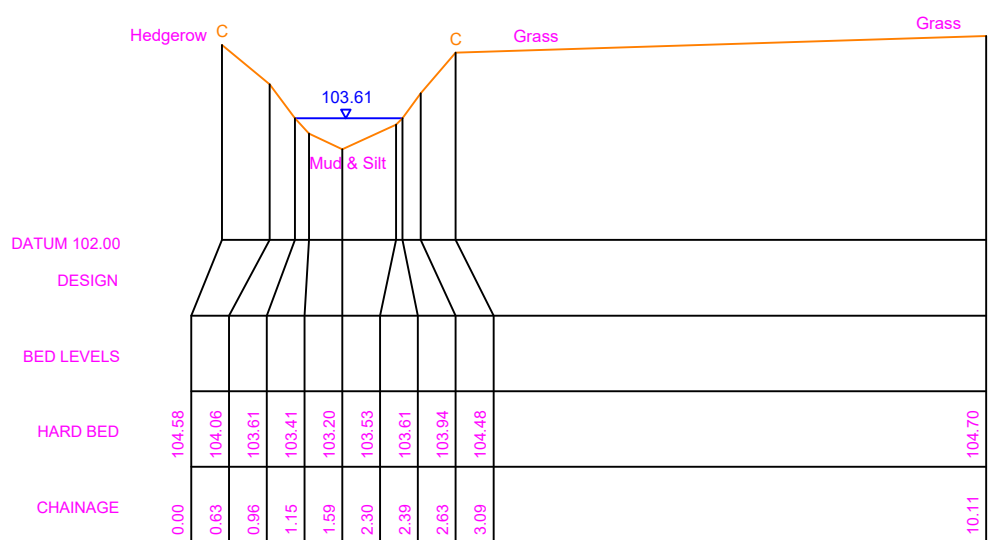
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HIN-BWB-03-ZZ-M2-G-0060

Status
S2

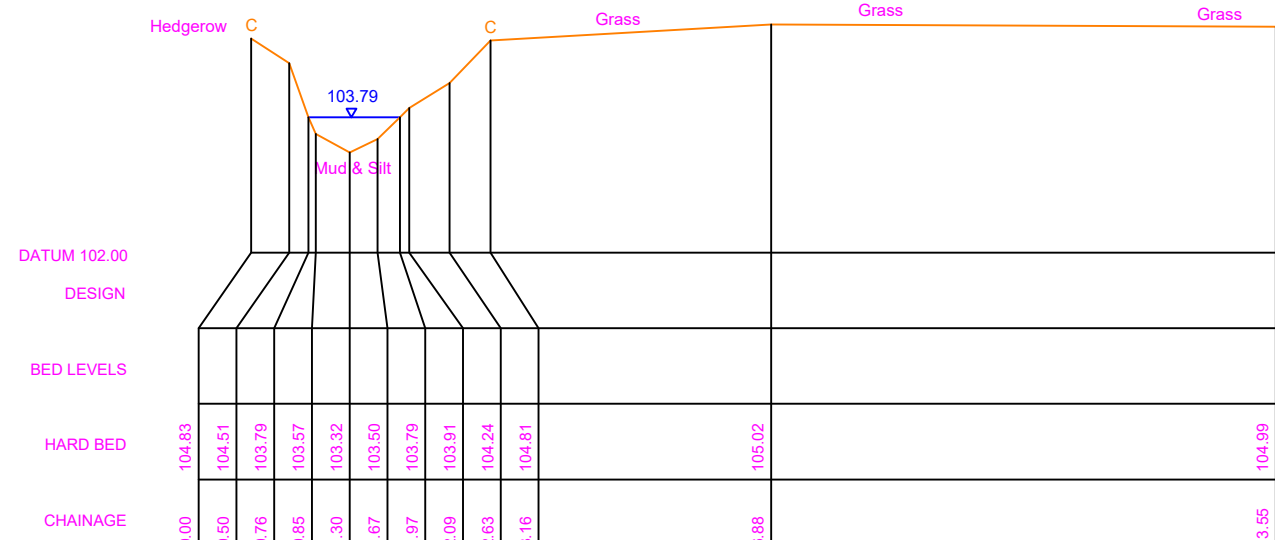
Rev
P1



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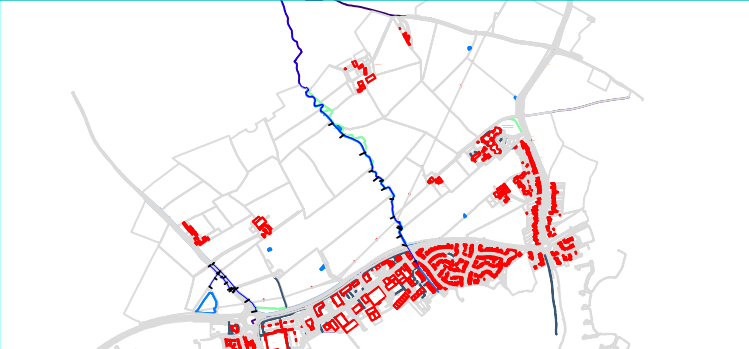


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Notes

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6. All coordinates and height data relate to OSGB36(15). Control stations are coordinated by means of GPS receiving real time corrections via OS smart net.
7. All manhole data is collected from ground level therefore discrepancies may occur. More accurate data is only achievable via confined space entry.
8. OS license number: 100022432

Key Plan



Legend

	OS Buildings		Contour Lines
	Surveyed Buildings		Inspection Chamber
	Building		Flow direction and pipe diameter
	Wall		Station and Name
	Kerb Channel Line		Monitoring Borehole
	Top of Kerb		Tree / Bush / Sapling
	Edge of Surface		Area of Vegetation/ Extent of Tree Canopy
	Top of Bank		Hedge
	Bottom of Bank		Body of Water
	Canopy / Overhang		Body of Water from OS
	Line Marking		Spot Level
	Centre Line		Assumed Surface
	Watercourse		Water Drainage Line
	Centre Line		Surface Water Drainage Line
	Barrier		
	Fence		
	Gate		
	Overhead Powerline		
	Overhead Utilities		

AP	Anchor Point	FBW	Fence Barbed Wire	LB	Litter Bin
BO	Back Gully	FOB	Fence Chain Board	LP	Lamp Post
BO	Bollard	FCL	Fence Chain Link	MH	Manhole
BS	Bus Stop	FEL	Fence Electric	Mv	Service Marker
BT	British Telecom	FMP	Fence Metal Panel	PS	Post Box
C	Crest	FMR	Fence Metal Rolling	PT	Post
CL	Cover Level	FOB	Fence Open Board	RE	Rodding Eye
CMP	Cable Marker	FPW	Fence Post & Wire	SP	Sign Post
Post	Post	FSP	Fence Steel Pile/ stake	ST	Stop Sign
CCTV/Security Camera	FWM	Fence Wire Mesh	SV	Stop Valve	
CIV	Cable TV	FPL	Fence Floor Level	TGB	Telephone Call Box
DC	Drainage	FP	Flagpole	THL	Threshold Level
DK	Drop Kerb	OV	Gas Valve	TL	Traffic Light
DP	Down Pipe	OY	Gully	TP	Telegraph Post
Elec	Electric	HS	Height	TS	Traffic Signal
EP	Electricity Post	IC	Inspection Chamber	UTS	Unable to Survey
ER	Earth Road	IFL	Internal Floor Level	VL	Valve Level
FH	Fire Hydrant	IL	Invert Level	WM	Water Meter
FL	Floodlight	(in a reduced level)		WO	Wash Out

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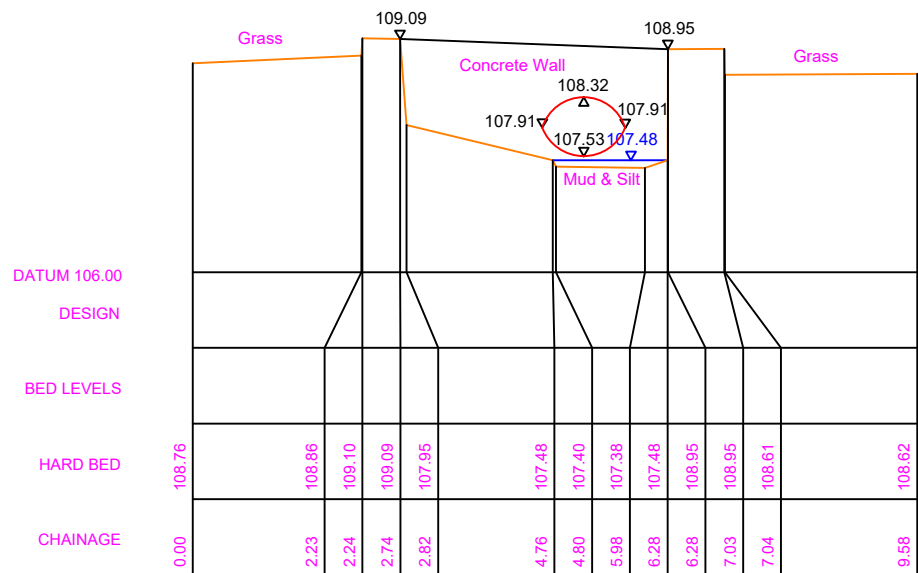
**WATERCOURSE SURVEY
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Drawn:	I.Riley	Reviewed:	D.Smith
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HIN-BWB-04-ZZ-M2-G-0060	S2	P1

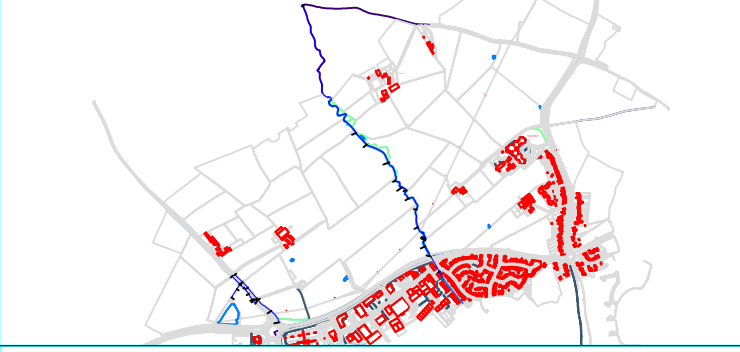


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Notes

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8. OS license number: 100022432

Key Plan



Legend

	OS Buildings		Contour Lines
	Surveyed Buildings		Inspection Chamber
	Building		Flow direction and pipe diameter
	Wall		Station and Name
	Kerb Channel Line		Monitoring Borehole
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	Top of Bank		Hedge
	Bottom of Bank		Body of Water
	Canopy / Overhang		Body of Water from OS
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	Centre Line		Assumed Surface
	Watercourse		Water Drainage Line
	Centre Line		Surface Water Drainage Line
	Barrier		
	Fence		
	Gate		
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	Overhead Utilities		

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BO	Bollard	FCL	Fence Chain Link	MH	Manhole
BS	Bus Stop	FEL	Fence Electric	MV	Service Marker
BT	British Telecom	FMP	Fence Metal Panel	PS	Post Box
C	Crest	FMR	Fence Metal Rolling	PT	Post
CL	Cover Level	FOB	Fence Open Board	RE	Rodding Eye
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CTV	Cable TV	FFL	Finished Floor Level	TGB	Telephone Call Box
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DK	Drop Kerb	OV	Gas Valve	TL	Traffic Light
DP	Down Pipe	GY	Gully	TP	Telegraph Post
Ele	Electric	HS	Height	TS	Traffic Signal
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FL	Floodlight		(as a reduced level)	WO	Wash Out

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**WATERCOURSE SURVEY
REACH 5
SHEET 5 OF 6**

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BWB Ref:	210683	Date:	09.02.22
Scale@A0:	1:100		

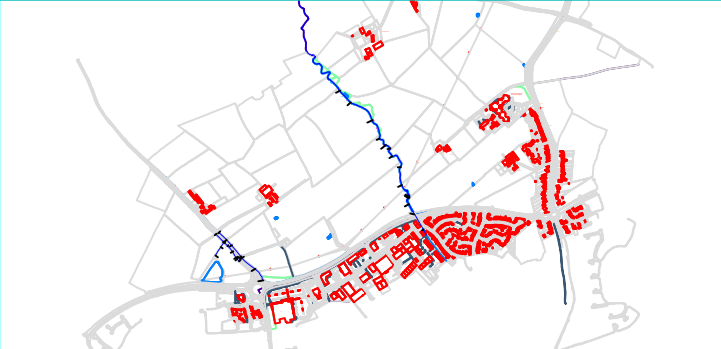
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Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
HIN-BWB-05-ZZ-M2-G-0060	S2	P1

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3. All dimensions in metres unless noted otherwise. All levels in metres unless noted otherwise.
4. Any discrepancies noted on site are to be reported to the engineer immediately.
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6. All coordinates and height data are to OSG93B(15). Control stations are coordinated by means of GPS receiving near true corrections via OSG.
7. All manhole data is collected from ground level therefore discrepancies may occur. More accurate data is only achievable via confined space entry.
8. OSG license number: 100022432

Key Plan



Legend

[illegible]

P1	09.02.22	First Issue	IR	Drw
Rev	Date	Details of issue / revision	Drw	Rev

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Drawn:	I.Riley	Reviewed:	D.Smith
PWP Ref:	210692	Date:	09.02.22
		Scale/Alt:	1:1250

Information

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
HIN-BWB-06-ZZ-M2-G-0060	S2	P1

Appendix 2: Hydrological Assessment

ENVIRONMENT

Richborough Estates Limited and Mr & Mrs
Adcock
Land East of Stoke Road and North of Normandy
Way (A47)
Hinckley
Flow Estimation Record

ENVIRONMENT

Richborough Estates Limited and Mr & Mrs Adcock
Land East of Stoke Road and North of Normandy Way (A47)
Hinckley
Flow Estimation Record

Birmingham
Livery Place, 35 Livery Street, Colmore Business District
Birmingham, B3 2PB
T: 0121 233 3322

Leeds
Whitehall Waterfront, 2 Riverside Way
Leeds, LS1 4EH
T: 0113 233 8000

London
11 Borough High Street
London, SE1 9SE
T: 0207 407 3879

Manchester
11 Portland Street
Manchester, M1 3HU
T: 0161 233 4260

Nottingham
5th Floor, Waterfront House, Station Street
Nottingham, NG2 3DQ
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March 2022

DOCUMENT ISSUE RECORD

Document Number:	HIN-BWB-ZZ-XX-RP-YE-0001_FER
BWB Reference:	210683-FER

Author:	Lucy Reeves BSc (Hons)
Checked:	Claire Gardner BSc (Hons) MSc MCIWEM C.WEM
Approved:	Max Brambani BSc (Hons) PgCert MCIWEM

Rev	Date	Status	Comment	Author:	Checked:	Approved:
P01	25/03/22	S2	Preliminary Issue	LR	CG	MB

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- (i) The date on which this assessment was undertaken, and
- (ii) The date on which the final report is delivered

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All Environment Agency mapping data used under special license. Data is current as of March 2022 and is subject to change.

The information presented, and conclusions drawn, are based on statistical data and are for guidance purposes only. The study provides no guarantee against flooding of the study site or elsewhere, nor of the absolute accuracy of water levels, flow rates and associated probabilities.

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1. METHOD STATEMENT

Overview of Requirements

- 1.1 Flow estimates are required for input into a hydraulic model of an Unnamed Ordinary Watercourse (UOW) and ditches within the vicinity of the site to quantify the flood risk posed to the development site. The UOW is located to the east of the site and forms a single eastern catchment. The ditches are located to and within the west of the site and form two western catchments. For the purposes of this assessment all features have been given a UOW site code prefix.
- 1.2 The location of the site of interest and the watercourses to be modelled are provided in **Figure 1.1**.

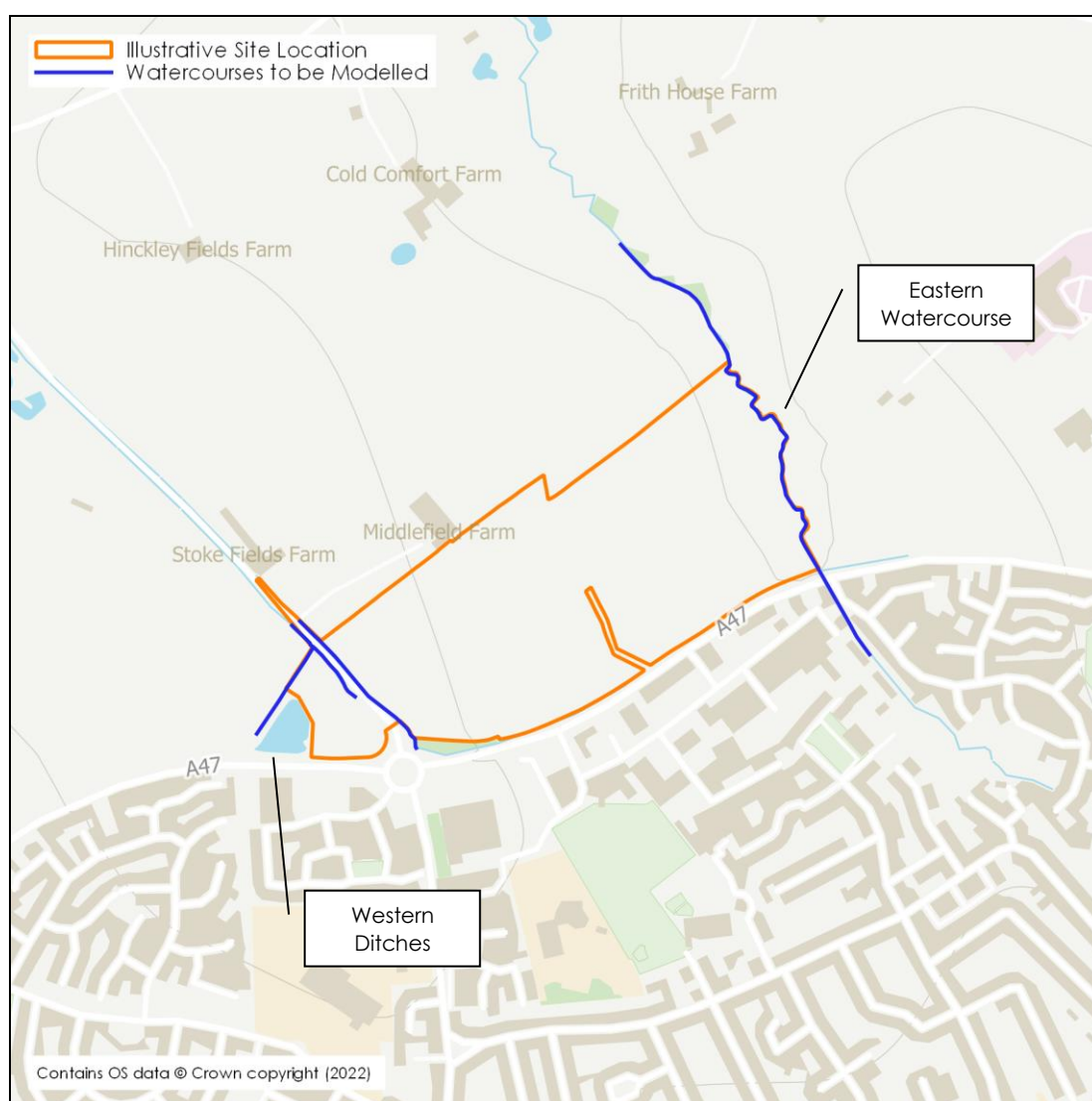


Figure 1.1: Site Location Plan

- 1.3 Return periods to be assessed include: 5, 10, 20, 50, 75, 100, 200 and 1000-years. To inform the design event and potential future floodplain, the 1 in 100-year event with a

range of climate change allowances applied will also be simulated. Hydrographs are required as well as peak flows.

- 1.4 The hydrological assessment was undertaken in February 2022. Version 5 of the Environment Agency (EA) Flood Estimation Guidelines¹ was referred to throughout the hydrological analysis.

Climate Change

- 1.5 Predicted future change in peak river flows caused by climate change are provided by the EA, with a range of projections applied to regionalised 'River Basin Districts', which are further sub-divided into 'Management Catchments'.
- 1.6 The catchments fall within the Tame Anker and Mease Management Catchment of the Humber River Basin District. **Table 1.1** identifies the relevant peak river flow allowances from this Management Catchment.

Table 1.1: Peak River Flow Allowance for the Tame Anker and Mease Management Catchment within the Humber River Basin District

Allowance Category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2125)
Upper End	24%	30%	51%
Higher Central	15%	17%	30%
Central	10%	11%	22%

- 1.7 When determining the appropriate allowance, the Flood Zone classification, flood risk vulnerability and the anticipated lifespan of a future development should be considered. **Table 1.2** provides a matrix summarising the EA's guidance on determining the appropriate allowances.

Table 1.2: Application of the Appropriate Climate Change Allowance

Flood Zone	Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water Compatible
1	Use the central allowance where a location may fall within Flood Zone 2 or 3 in the future.				
2	Use the higher central allowance	Use the central allowance			
3a	Use the higher central allowance	Development should not be permitted	Use the central allowance		

¹ Technical Guidance 197_08 Flood Estimation Guidelines, Environment Agency (June 2020)

Flood Zone	Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water Compatible
3b	Use the higher central allowance	Development should not be permitted			Use the central allowance
*If development is considered appropriate when not in accordance with Flood Zone vulnerability categories, then it would be appropriate to use the upper end allowance.					

Available Hydrometric Data

- 1.8 There are no hydrometric gauges within the catchments. Therefore, there are no current hydrometric records of river flows or levels for the watercourse on which a hydrological assessment of flood flows can be made.
- 1.9 The National River Flow Archive (NRFA) Peak Flow Dataset Version 10 (released 27 August 2021) will also be utilised in this assessment for the purposes of identifying any potential donor stations and for the development of pooling groups.

Initial Choice of Approach

Table 1.3: Method Statement

Is FEH appropriate?	Yes. Although the catchments are very small and the upper reaches are heavily urbanised, FEH methods are now the preferred methods for small catchments as well as being suitable for heavily urbanised catchments.
Initial choice of method(s) and reason	Both the FEH Statistical and the ReFH2 methods will be used. Both methods are suitable for the catchments and using both will enable comparison between the two flow estimation methods.
Software to be used	WINFAP v5 and ReFH2 version 2.3

2. LOCATIONS WHERE FLOOD ESTIMATES ARE REQUIRED

Location of Flow Estimates

- 2.1 The eastern watercourse was well-represented within the FEH web service. Therefore, the flow estimation point for this catchment was taken at the downstream extent of the hydraulic model.
- 2.2 The western ditches are not well-represented within the FEH web service. The ditches to be modelled are not shown in the FEH. However, the FEH does show a watercourse starting at a pond just north of the A47. Although this watercourse is misaligned with the ditches to be modelled, it does cover part of the catchments of interest and, therefore, was considered suitable for providing initial catchment descriptors for deriving inflows for the western hydraulic models (catchment descriptors were reviewed and amended accordingly, see **Table 2.2**).
- 2.3 It was decided to calculate flows at the downstream extent of the watercourses only due to the relatively small difference in catchment areas between the upstream and downstream extents of the models.

Table 2.1: Summary of Subject Sites

Site code	Watercourse	Site	Easting	Northing	Area on FEH Webservice	Revised area (if altered)
Eastern Watercourse						
UOW001	Unnamed Ordinary Watercourse	Rogue's Lane	441950	296750	2.3	2.1
Western Ditches						
UOW002	Unnamed Ordinary Watercourse	Farm Track adjacent to Stoke Road	441450	295550	1.0	0.7
UOW003	Unnamed Ordinary Watercourse	Farm Track adjacent to Stoke Road	441450	295550	1.0	0.3

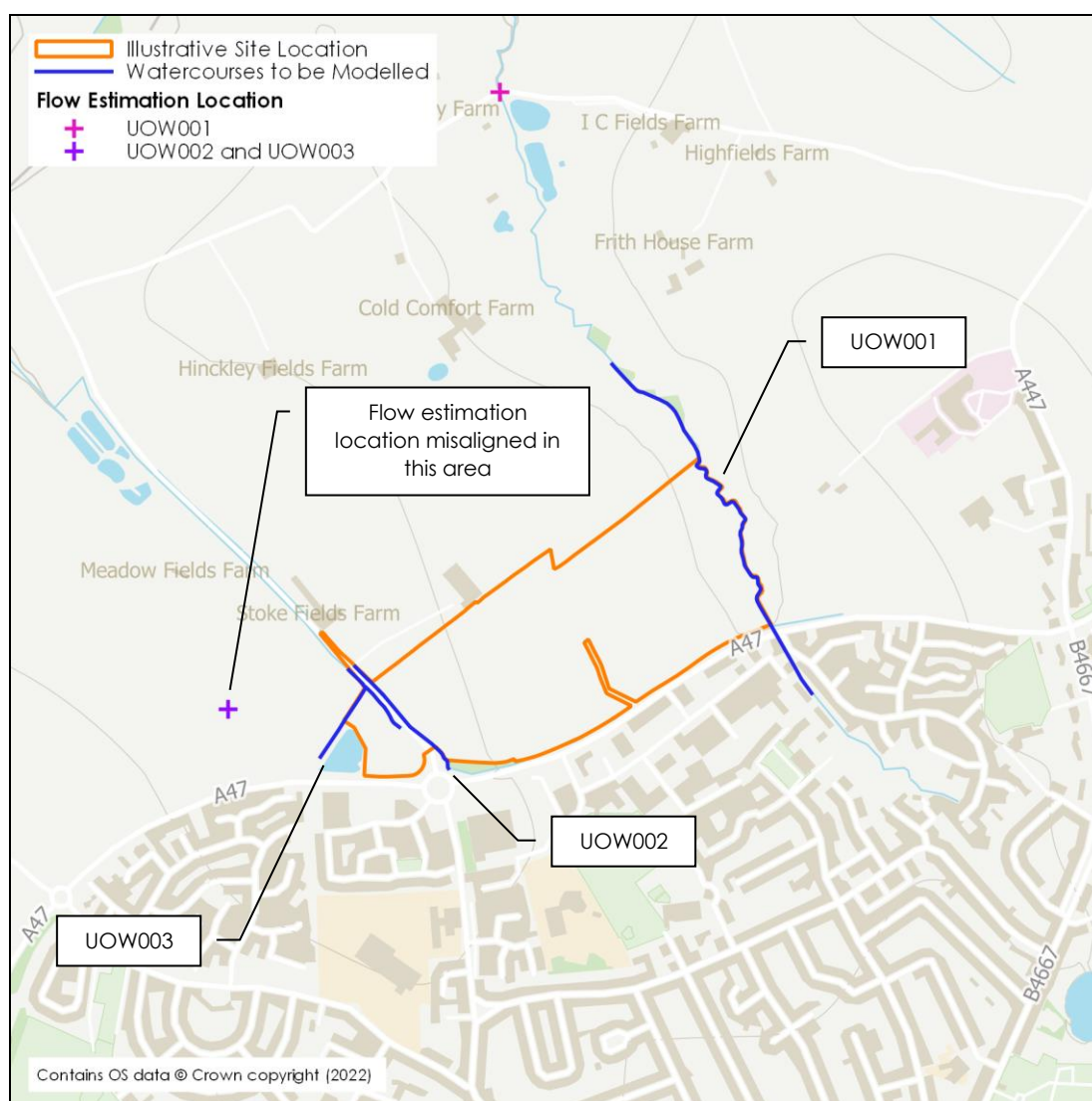


Figure 2.1: Flow Estimation Locations

Checking Catchment Descriptors

Table 2.2: Catchment Descriptor Checks

Record how catchment boundary was checked and describe any changes.	The catchment boundaries for the flow estimation points were identified by the Flood Estimation Handbook (FEH) web service. The boundaries were reviewed and updated using a combination of Ordnance Survey mapping, EA LiDAR and sewer records, where available. Adjustments were required, as demonstrated in Figure 2.2 , Figure 2.3 and Figure 2.4 .
Record how other catchment descriptors (especially soils) were checked and describe any changes. Include before/after table if necessary.	The British Geological Survey (BGS) mapping indicates that the watersheds are predominately underlain by the Mercia Mudstone Group. Superficial deposits of Alluvium (Clay, Silt, Sand and Gravel), Bosworth Clay Member (Clay and Silt), Wolston Sand and Gravel and Oadby Member (Diamicton) are also expected to be present throughout the catchments.

	The underlying geology and soils suggest the BFIHOST and SPRHOST values of the FEH catchment descriptors are appropriate for the catchments. The FARL value was checked against OS mapping and was considered representative of the surface water features in the catchments. URBEXT₂₀₀₀ was updated following the changes to the catchment boundaries. DPLBAR has been updated using the standard equation for DPLBAR, given in the FEH Volume 5.
Source of URBEXT	The URBAN50k method has been used to calculate URBEXT₂₀₀₀ for the revised catchment boundaries. FARL was adjusted using the FEH procedure outlined in Volume 5 of the FEH Handbook.
Method for updating of URBEXT to present day.	An update to the current year is not required as the URBAN50k method has been used to calculate URBEXT₂₀₀₀. As such the current urban extent will be implicitly accounted for in the latest mapping.

Table 2.3: Important Catchment Descriptors at Each Subject Site (changes made are highlighted in red)

Site Code	FARL	PROPWET	BFIHOST19	DPLBAR (km)	DPSBAR (m/km)	SAAR	SPRHOST	URBEXT 2000 *	FPEXT
Eastern Watercourse									
UOW001	0.951	0.3	0.427	1.52	28	654	44.67	0.2910	0.048
Western Ditches									
UOW002	1	0.3	0.395	0.85	20.3	652	43.8	0.3910	0.1667
UOW003	1	0.3	0.395	0.52	20.3	652	43.8	0.3732	0.1667

* URBEXT₂₀₀₀ updated to 2022

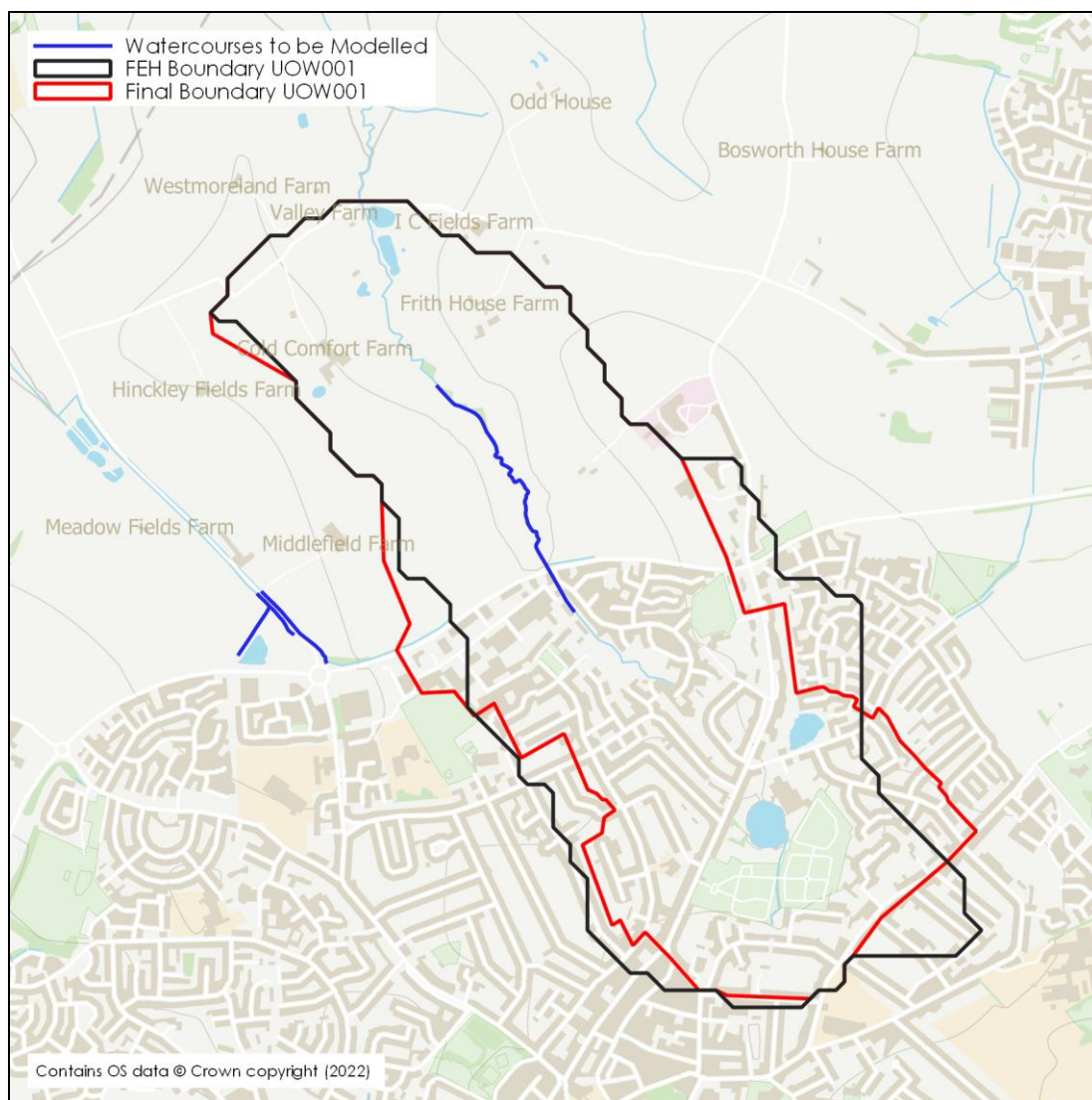


Figure 2.2: Original and Amended Catchment Boundaries – UOW001

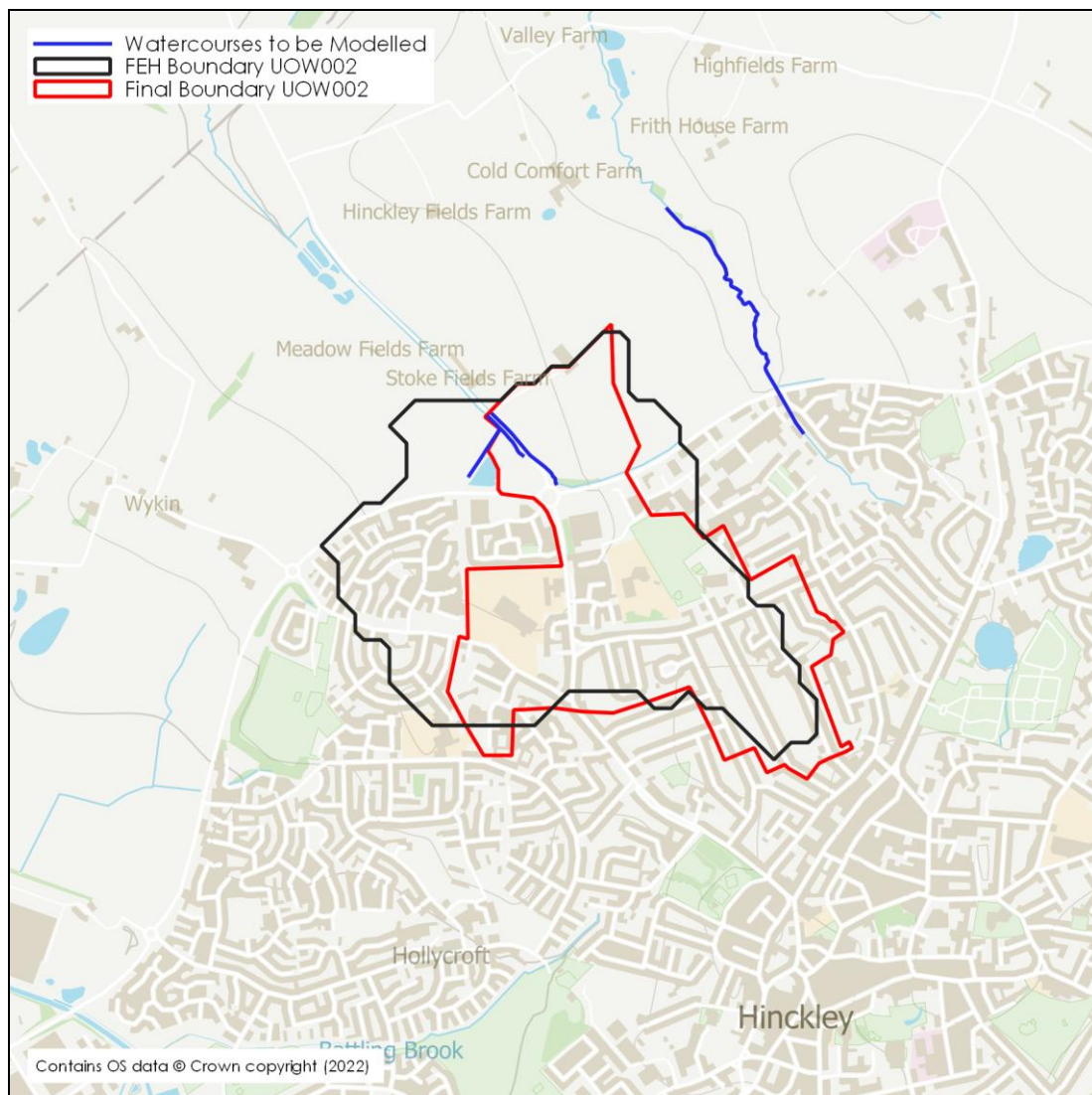


Figure 2.3: Original and Amended Catchment Boundaries – UOW002

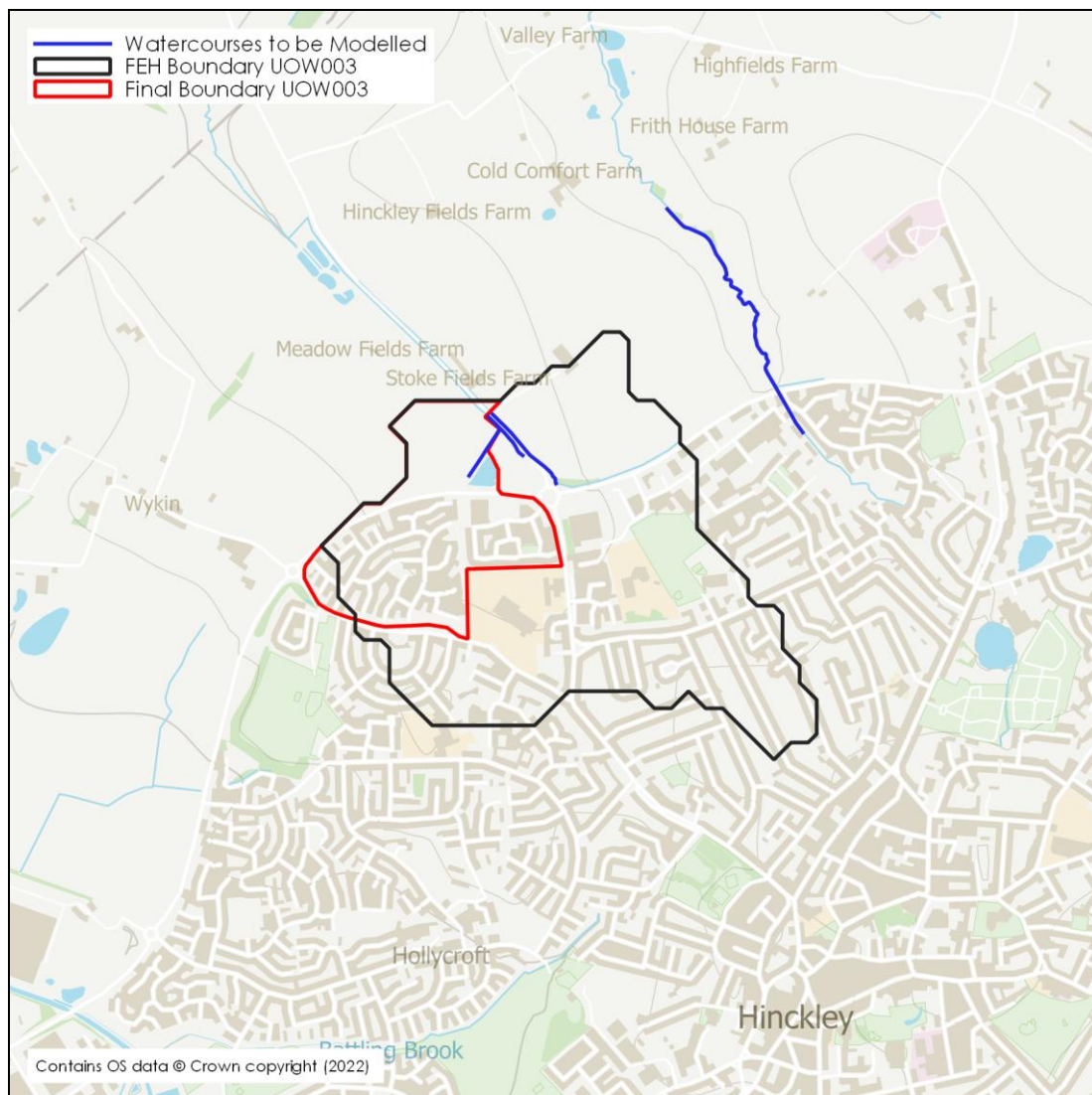


Figure 2.4: Original and Amended Catchment Boundaries – UOW003

3. STATISTICAL METHOD

- 3.1 WINFAP was utilised to undertake a statistical analysis of the catchments using a hydrometric record of gauged catchments with similar characteristics.

QMED Development

- 3.2 Catchment descriptors were originally used to estimate the rural QMED of the study site using the revised equation from Science Report (SC050050). The FEH states that flood frequency is best estimated by gauged data and estimation of key variables from catchment descriptors alone should be a method of last resort. As such, a search was undertaken to identify any potential donor sites that could be used to adjust QMED.
- 3.3 Phase 2 of Science Report SC090031² recommends using a single donor, chosen on the basis of proximity, to adjust QMED for 'small catchments' (defined as catchments with an area of less than 25km²). This method can also be applied to catchments less than 40km².
- 3.4 Whilst the FEH recommends avoiding urbanised donors, the Littlethorpe gauge (NRFA reference: 28082) is approximately 12km from the site and only just over the 0.03 threshold for URBEXT₂₀₀₀. WINFAP allows the use of urban donors, applying the urban adjustment factor in reverse to attempt to remove the urban influence. As such, the search for donors was extended to donors with URBEXT > 0.046 to allow WINFAP to include Littlethorpe as a donor.
- 3.5 With the guidance in mind, a search was undertaken within WINFAP to identify the closest station to the flow estimation point(s). The data quality of potential donor(s) was also reviewed. Of the recommended donors, the following were rejected:
- 28026 – flow bypasses on the left bank, variable drowning due to weed growth and substantial modification owing to Public Water Supply (PWS) imports.
- 3.6 Details for the donor station(s) used to adjust QMED, and which flow estimation point(s) they have been applied to, are provided in **Table 3.1**. Details of the donor adjustment(s) and final QMED estimation are provided in **Table 3.2**.

² Science Report SC090031/R0: Estimating flood peaks and hydrographs for small catchments (Phase 2), Environment Agency (2019).

Table 3.1: Donor Station Details

Station Number	QMED from Observed Data (A)* (m ³ /s)	QMED from Catchment Descriptors (B)** (m ³ /s)	Adjustment Ratio (A/B)	Flow estimation point(s) donor is applied to
28082	15.58	18.593	0.84	UOW001 UOW002 UOW003

* The default, deurbanised observed data was used

** The default, rural, QMED from catchment descriptors was used

Table 3.2: Overview of Estimation of QMED at Each Subject Site

Site Code	Method	Initial Estimate of QMED (M ³ /s) (Rural)	Data Transfer				Final estimate of QMED (URBAN)
			Donor site NRFA no	Distance between centroids d _j (km)	Power term, a	Moderated QMED adjustment factor (A/B) ^a	
Eastern Watercourse							
UOW001	Donor Transfer	0.43	28082	25.71	0.275	1	0.57
Western Ditches							
UOW002	Donor Transfer	0.22	28082	26.11	0.273	1	0.32
UOW003	Donor Transfer	0.10	28082	26.11	0.273	1	0.15
Are the values of QMED consistent, for example at successive points along the watercourse and at confluences?				QMED is consistent with the size and characteristics of the catchments.			
Which version of the urban adjustment was used for QMED?				Urban adjustment was applied using Kjeldsen (2010), as applied in WINFAP.			

Derivation of Pooling Groups

- 3.7 A pooled group of hydrologically similar gauged sites was generated by the WINFAP software for the subject sites using the 'OK for Pooling' dataset. WINFAP uses the deurbanised pooling group L-moments as default.
- 3.8 Similarly to QMED estimations, the 'small catchment' method was adopted within WINFAP, in which the pooling group is selected using a similarity measure that only considered AREA and SAAR, as recommended by SC090031.
- 3.9 The catchments for all flow estimation locations were similar in size and characteristics and, therefore, the same pooling group was used.

- 3.10 The pooling group was reviewed to identify sites which may be inappropriate due to being significantly hydrologically dissimilar to the study site, or if they have any inaccuracies, uncertainties, or limitations in their data record.
- 3.11 As the final pooling group contained some permeable catchments (SPRHOST<20%), permeable adjustment was undertaken using WHS Permeable Adjustment Worksheet Beta v1.2.
- 3.12 The growth curve derived from the pooling group was also adjusted to reflect the urban influence using the methods adopted in WINFAP³ which is based on those published by Kjeldsen 20104.
- 3.13 Further detail on pooling group composition is provided in **Section 6**.

Table 3.3: Derivation of Pooling Groups

Name of group	Site code from whose descriptors the group was derived	Subject site treated as gauged? (enhanced single site analysis)	Change made to default pooling group with reasons, including any sites investigated but retaining in the group	Weighted average L-moments L-CV and L-skew (before urban and permeable adjustment)
HIN_PG	UOW001	No	Stations Removed: 7011 – short record (<8 years of data) 44008 – non-flood years account for >15% of the record Stations Added: N/A Comments: The pooling group is heterogeneous and a review of the pooling group is desirable. It is not considered possible to improve the pooling group any further.	L-CV: 0.266 L-Skew: 0.249

³ Wallingford HydroSolutions (2016), WINFAP 4 Urban adjustment procedures, Wallingford HydroSolutions Ltd 2016.

⁴ Kjeldsen, T.K., 2010. Modelling the impact of urbanization on flood frequency relationships in the UK. Hydrology Research, volume 41, issue 5, pp391-405

Table 3.4: Derivation of Flood Growth Curves at Subject Sites

Site code	Method (SS, P, ESS)	If P, ESS or J, name of pooling group	Distribution used and reason for choice	Note any urban or permeable adjustment	Growth factor for 1% AEP event
Eastern Watercourse					
UOW001	P	HIN_PG	Generalised logistic provided an acceptable fit and is regarded as the best fit for UK catchments and is the distribution used in the WHS Permeable Adjustment Worksheet Beta v1.2	Urban adjustment using methods adopted in WINFAP which is based on those published by Kjeldsen 2010 Permeable adjustment using WHS Permeable Adjustment Worksheet Beta v1.2	3.12
Western Ditches					
UOW002	P	HIN_PG	Generalised logistic provided an acceptable fit and is regarded as the best fit for UK catchments and is the distribution used in the WHS Permeable Adjustment Worksheet Beta v1.2	Urban adjustment using methods adopted in WINFAP which is based on those published by Kjeldsen 2010	3.06
UOW003	P	HIN_PG	Generalised logistic provided an acceptable fit and is regarded as the best fit for UK catchments and is the distribution used in the WHS Permeable Adjustment Worksheet Beta v1.2	Permeable adjustment using WHS Permeable Adjustment Worksheet Beta v1.2	3.07

Table 3.5: Flood Estimates from the Statistical Method

Site Code	Flood peak (m ³ /s) for the following return periods								
	2	5	10	20	50	75	100	200	1000
Eastern Watercourse									
UOW001	0.6	0.8	1.0	1.2	1.5	1.7	1.8	2.2	3.5
Western Ditches									
UOW002	0.3	0.4	0.5	0.6	0.8	0.9	1.0	1.2	1.9
UOW003	0.2	0.2	0.2	0.3	0.4	0.4	0.5	0.6	0.9

4. REVITALISED FLOOD HYDROGRAPH (ReFH) METHOD

- 4.1 The ReFH2 Revitalised Flood Hydrograph Modelling Tool (Version 2.3) was used to undertake an estimation of the peak flows for the subject sites.

Table 4.1: Overview of Parameters for ReFH2 Method

Site code	Method OPT: Optimisation BR: Baseflow recession fitting CD: Catchment descriptors DT: Data transfer	Tp (hours) Time to peak	C _{max} (mm) Maximum storage capacity	BL (hours) Baseflow lag	BR Baseflow recharge
ALL	Parameters calculated using catchment descriptors.				
Description of flood event analysis carried out			No flood event analysis was possible due to a lack of gauged data for the catchments.		

Table 4.2: ReFH2 Recommended Storm Durations

Site code	Season of design event	Storm duration	Selected interval
Eastern Watercourse			
UOW001	Winter	5.5hrs	0.5hr
Western Ditches			
UOW002	Summer	4.5hrs	0.5hrs
UOW003	Summer	3.25hrs	0.25hrs
Comments	The ReFH2 recommended storm duration and seasons will be taken forward with the modelling and will be used to derive model inflow hydrographs for the watercourse and ditches. As the modelled reach is short, with only a relatively small change in catchment areas between the upstream and downstream model extents, it was not considered necessary to test sensitivity to storm duration.		

Table 4.3: Flood Estimates from the ReFH Method (based on recommended duration for individual catchments)

Site Code	Flood peak (m ³ /s) for the following return periods								
	2	5	10	20	50	75	100	200	1000
Eastern Watercourse									
UOW001	0.6	0.8	1.0	1.2	1.4	1.6	1.7	2.1	3.1
Western Ditches									
UOW002	0.3	0.5	0.6	0.7	0.8	0.9	1.0	1.3	2.0
UOW003	0.2	0.2	0.3	0.3	0.4	0.5	0.5	0.6	1.0

5. DISCUSSION AND SUMMARY OF RESULTS

Comparison of Method

- 5.1 A comparison of the peak flow results for the different estimation methods for the 1 in 2-year and 1 in 100-year events is provided in **Table 5.1**. Comparisons of the growth curves for both methods are shown in **Figure 5.1**, **Figure 5.2** and **Figure 5.3**.

Table 5.1: Comparison of Results

Site code	1 in 2-year peak flows			1 in 100-year peak flows		
	Statistical	ReFH	Ratio	Statistical	ReFH	Ratio
Eastern Watercourse						
UOW001	0.6	0.6	1.0	1.8	1.7	0.9
Western Ditches						
UOW002	0.3	0.3	1.0	1.0	1.0	1.0
UOW003	0.2	0.2	1.0	0.5	0.5	1.0

- 5.2 The Statistical Method provides a steeper growth curve when compared to the ReFH2 Method for UOW001. The Statistical Method provides greater flows for the greater return periods, however for the smaller return periods, flow remain similar.
- 5.3 The Statistical Method and ReFH2 Method provide similar growth curves for UOW002. The ReFH2 Method and Statistical Method provide similar flows.
- 5.4 The ReFH2 Method provides a steeper growth curve when compared to the Statistical Method for UOW001. The ReFH2 Method and Statistical Method provide similar flows.

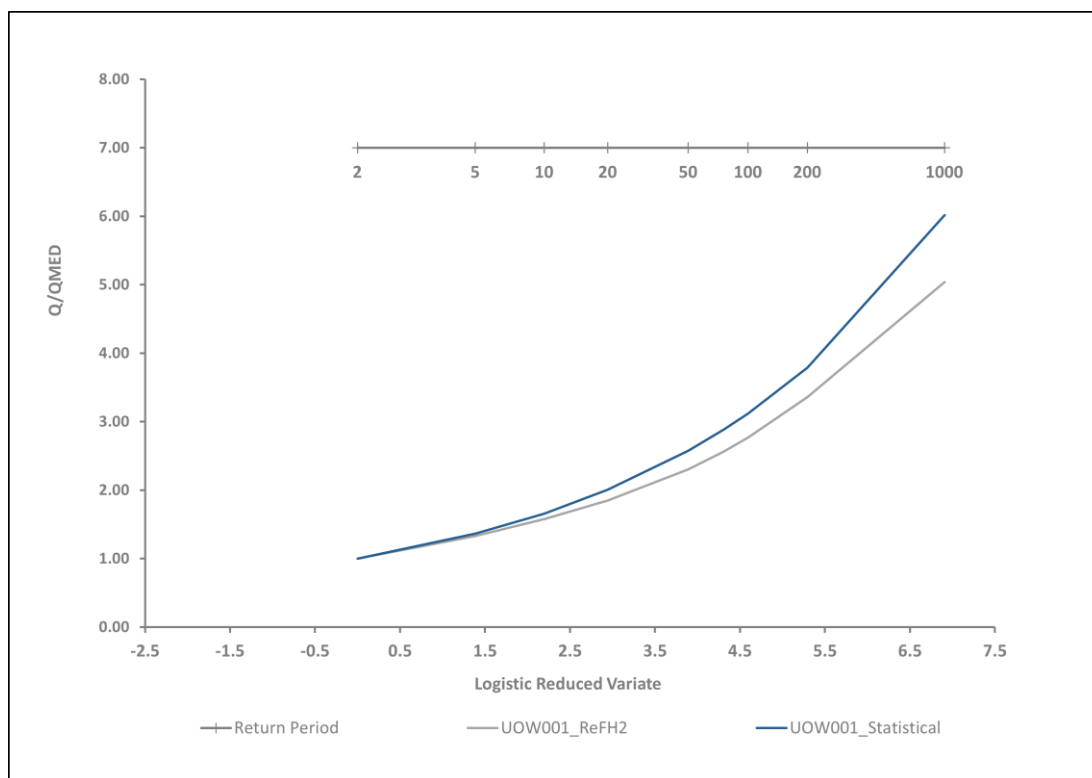


Figure 5.1: Comparison of Statistical Method and ReFH Growth Curves - UOW001

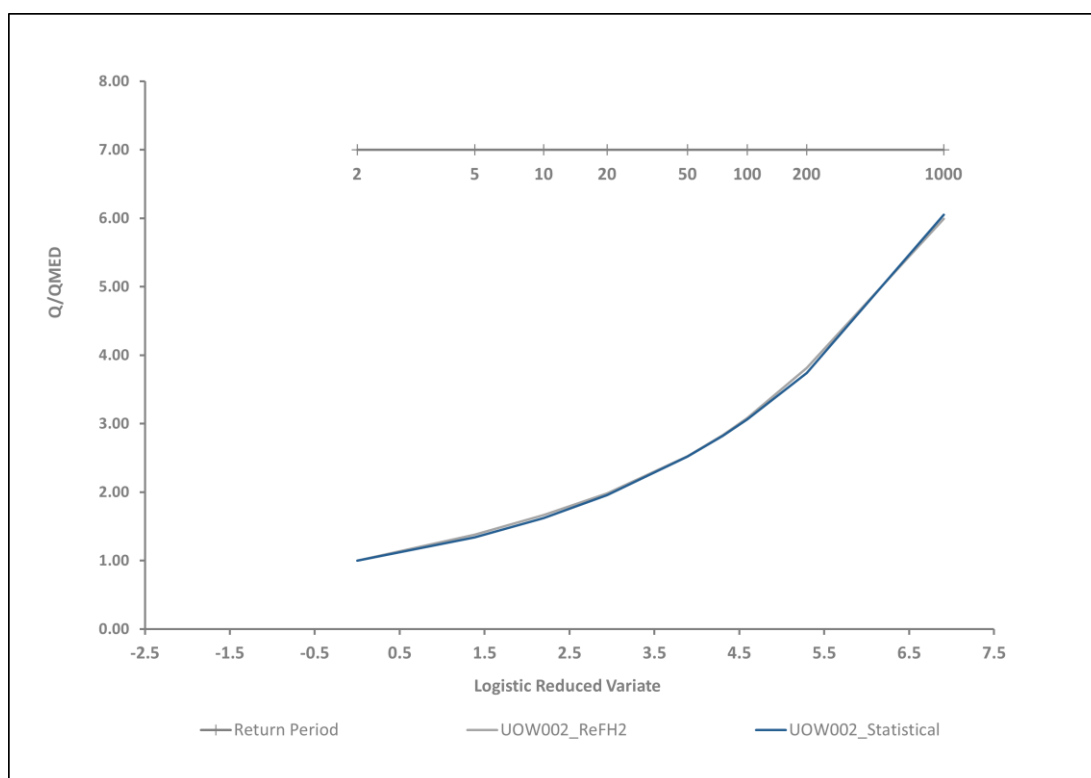


Figure 5.2: Comparison of Statistical Method and ReFH Growth Curves - UOW002

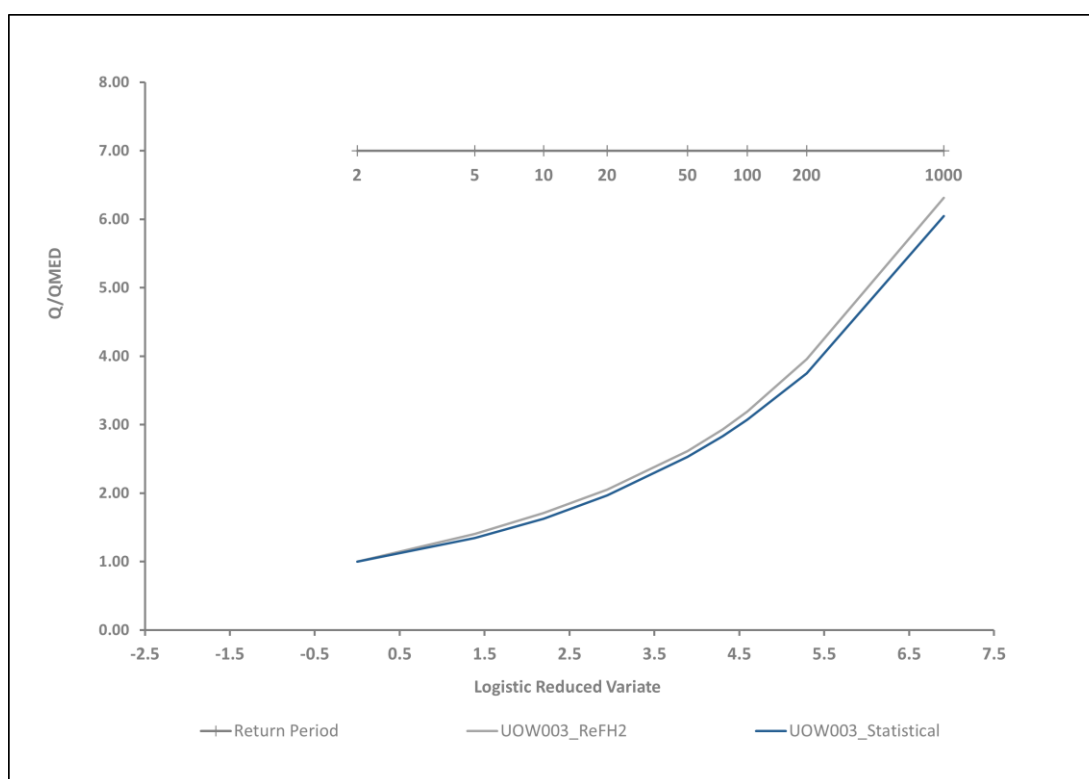


Figure 5.3: Comparison of Statistical Method and ReFH Growth Curves - UOW003

Final Method and Flows

Table 5.2: Final Choice of Method

Choice of method and justification

Whilst both Statistical and ReFH2 methods are considered suitable for UOW001, the final choice of peak flows for input into the model is the Statistical Method, in line with EA FEH Guidelines recommendation. The Statistical Method benefits from an up-to-date flood peak dataset, using growth curves from hydrologically similar catchments to derive a growth curve. The Statistical Method also benefits by avoiding the need to make assumptions about factors such as rainfall duration, time of concentration and the nature of the design flood, unlike the ReFH2 Method.

ReFH2 will be used to provide a hydrograph shape for the UOW001 model inflows, scaled to the Statistical peak.

Whilst both Statistical and ReFH2 methods are considered suitable for UOW001, the final choice of peak flows for input into the model is the ReFH2 Method. Whilst the Statistical method is generally the preferred method set out in the EA Guidelines, for the ditches, the flow estimates being calculated for are not real topographic catchments, with their upper reaches defined by sewer catchments. As such, the FEH Statistical method is not strictly applicable and ReFH 2 was preferred due to the influence of sewers at the upstream extent of the ditches.

Table 5.3: Final Peak Flows for the Eastern Watercourse from Chosen Method (Statistical)

Site Code	Flood peak (m ³ /s) for the following return periods								
	2	5	10	20	50	75	100	200	1000
UOW001	0.6	0.8	1.0	1.2	1.5	1.7	1.8	2.2	3.5

Table 5.4: Final Peak Flows for the Western Ditches from Chosen Method (ReFH)

Site Code	Flood peak (m ³ /s) for the following return periods								
	2	5	10	20	50	75	100	200	1000
UOW002	0.3	0.5	0.6	0.7	0.8	0.9	1.0	1.3	2.0
UOW003	0.2	0.2	0.3	0.3	0.4	0.5	0.5	0.6	1.0

Table 5.5: Assumptions, Limitations and Uncertainty

List the main assumptions made	- The pooling groups are representative of the catchments. - The ReFH2 hydrograph shape is representative of the catchment responses. - Tp and storm duration is representative of the catchment responses. - The flow estimate derived at the downstream extent of the watercourses is applicable to the upstream catchments. - It is assumed that the misaligned FEH catchment is representative of the catchments associated with the western ditches. - It is assumed that FEH methods are suitable for the western ditches, although they are not strictly 'real' catchments.
Discuss any limitations e.g. applying methods outside the range of catchment types or return periods for which they were developed	- The FEH Statistical and ReFH2 methods are believed to be suitable up to the 1 in 200-year event. Estimates of flow beyond these events are extrapolations and, therefore, have a higher level of uncertainty. - There are only a small number of gauged sites in the UK. As such the representation in the pooling is not ideal given the small size of some of the study catchments. - There is no observed flow data within the catchments with which to verify the flow estimates.
Give what information you can on uncertainty in the results	Section 5.4 sets out confidence intervals for the Statistical method at ungauged sites. However, confidence intervals for heavily urbanised sites are not provided because there are not enough suitable catchments with flood peak data to provide reliable results.

	Donor transfer has been undertaken using data from a nearby gauge. Use of a donor station is considered to provide more reliable estimates compared to those calculated from catchment descriptors alone. It is more difficult to quantify uncertainty in design flows estimated from the ReFH rainfall-runoff model. However, evidence⁵ suggests the factorial standard errors from ReFH2 are comparable to those observed for the FEH pooled Statistical method when the catchment is treated as ungauged.
Comment on the suitability of the results for future studies	The design flow estimates have been derived for the purpose of providing flow hydrographs into a hydraulic model to support an understanding of flood risk at the development site. Users for different studies should, as a minimum, review results to assess suitability for the purpose of the study.
Give any other comments on the study	While the installation of temporary flow gauges would provide local data with which to better inform the design peak flows, this would not align with the timescales of this project.

Table 5.6: Checks

Are the results consistent?	Peak flows are consistent with the size and characteristics of the catchments.
What do the results imply regarding the return periods of floods during the period of record?	A flood history review for the area has been undertaken (Section 6). The Level 1 SFRA notes that a surface water overland flow route exists along Stoke Road and is associated with an unnamed drain adjacent to this road; however there are no historical flooding incidents recorded. There is no detailed information available for this event and no hydrometric data available for the catchments.
What is the 1 in 100-year growth factor? (the guidance suggests a typical range or 2.1 to 4.0)	- The 1 in 100-year growth factor for the Statistical Method is 3.12 for UOW001, 3.06 for UOW002 and 3.07 for UOW003. - The 1 in 100-year growth factor for the ReFH2 Method is 2.77 for UOW001, 3.08 for UOW002 and 3.19 for UOW003. These fall within the typical range.
If 1 in 1000-year flows have been derived, what is the range of ratios for 1 in 1000-year flow over 1 in 100-year flow?	- Statistical Method: ratio for UOW001 is 1.93, for UOW002 is 1.98 and for UOW003 is 1.97. - ReFH2 Method: ratio for UOW001 is 1.82, for UOW002 is 1.94 and for UOW003 is 1.98.

⁵ Wallingford Hydrosolutions (2019) ReFH2 Science Report: Evaluation of the Rural Design Event Model.

How do the results compare with those of other studies? Explain any differences and conclude which results should be preferred	There are no previous studies with which to compare results.
Are the results consistent with the longer-term flood history?	A flood history review has been undertaken and the Level 1 SFRA notes that a surface water overland flow route exists along Stoke Road and is associated with an unnamed drain adjacent to this road, however there are no historic flooding incidents recorded. It is unknown whether this surface water flow route affects the development site. No specific details on the flows are recorded and there is no hydrometric data within the catchments with which to compare.
Describe any other checks on the results	Sensibility checks of modelled outlines will be undertaken at the modelling stage.

Application of Flows to Model

5.5 Flows will be applied to the model in the following way.

UOW001

- i. To derive hydrographs for UOW001, the ReFH2 hydrographs were scaled to meet the Statistical Method peak flows.
- ii. The model extent was located further upstream than the flow estimation location and, therefore, the flows were pro-rated to cover a catchment that would drain to the extent of the watercourse modelled.
- iii. Normandy Way, located to the south of the site, represents a catchment division. Therefore, the inflows have been prorated between the upstream and downstream catchment of Normandy Way.
- iv. Two surface water sewers are understood to outfall to the UOW adjacent to Normandy Way; therefore an inflow was applied to each of the sewers at the head of the run. The inflows were prorated between each of the sewers and the UOW.

5.6 **Figure 5.4** demonstrates how the flows will be applied to the model for UOW001.

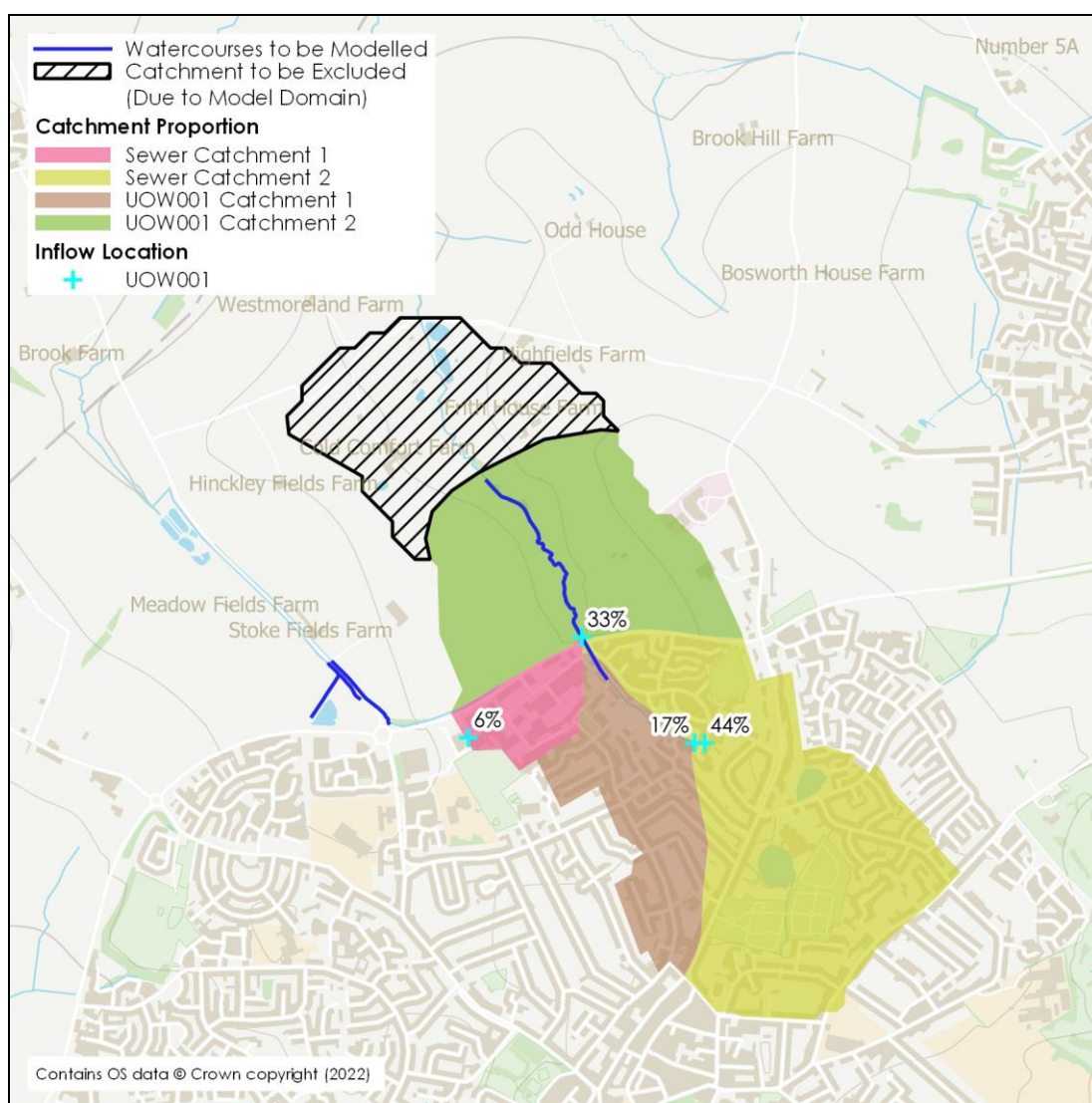


Figure 5.4: Application of Inflows into Model – UOW001

UOW002

- i. ReFH2 hydrographs were used and applied to the model.
- ii. Normandy Way, located to the south of the site, represents a catchment division. Therefore, the inflows have been prorated between the upstream and downstream catchment of Normandy Way.
- iii. Two surface water sewers are understood to outfall to the UOW adjacent to Normandy Way, therefore an inflow was applied to each of the sewers at the head of the run. The inflows were prorated between each of the sewers and the UOW.

5.7 **Figure 5.5** demonstrates how the flows will be applied to the model for UOW002.

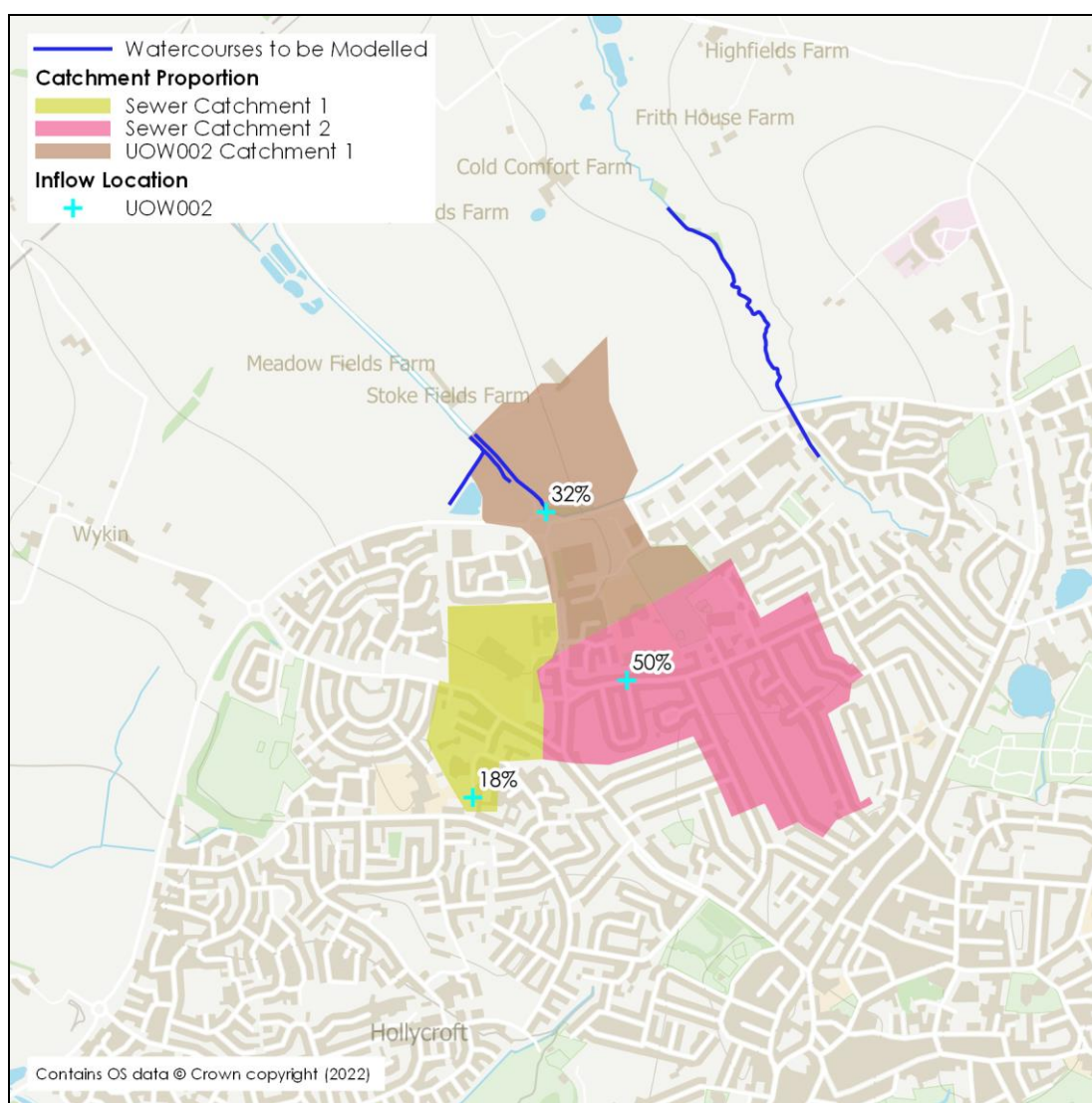


Figure 5.5: Application of Inflows into Model – UOW002

UOW003

- i. ReFH2 hydrographs were used and applied to the model.
- ii. Normandy Way, located to the south of the site, represents a catchment division. Therefore, the inflows have been prorated between the upstream and downstream catchment of Normandy Way.
- iii. One surface water sewer is understood to outfall to the UOW adjacent to Normandy Way, therefore an inflow was applied to the sewers at the head of the run. The inflows were prorated between each of the sewers and the UOW.

5.8 **Figure 5.6** demonstrates how the flows will be applied to the model for UOW003.

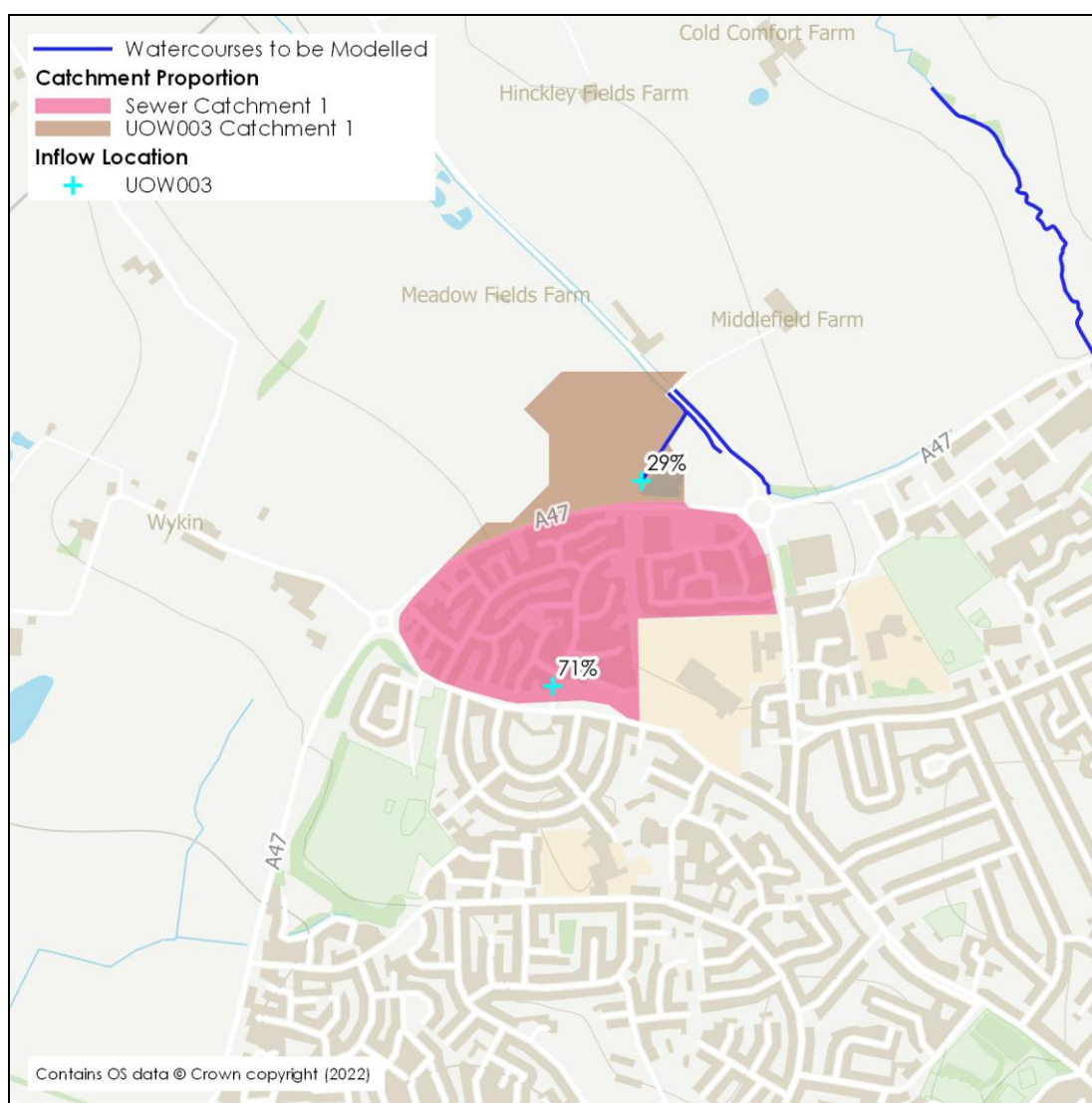


Figure 5.6: Application of Inflows into Model – UOW003

6. SUPPORTING INFORMATION

Flood History

- 6.1 A flood history review for the catchments has been undertaken using EA recorded flood outlines, Hinckley and Bosworth Borough Council Level 1 Strategic Flood Risk Assessment (SFRA)⁶, Hinckley and Bosworth Borough Council Level 2 SFRA⁷, Leicestershire County Council Preliminary Flood Risk Assessment (PFRA)⁸, Leicestershire County Council Local Flood Risk Management Strategy (LFRMS)⁹, the British Chronology of Hydrological Events and online newspaper records.
- 6.2 The Level 1 SFRA notes that a surface water overland flow route exists along Stoke Road and is associated with an unnamed drain adjacent to this road, however there are no historic flooding incidents recorded. It is unknown whether this surface water flow route affects the development site.

Detailed Pooling Group Information

- 6.3 The default pooling group generated by WINFAP is provided in **Table 6.1** and the final pooling group following review is provided in **Table 6.2**. Permeable adjusted L-CV and L-Skew are provided in **Table 6.3**.

Table 6.1: Default Pooling Group: HIN_PG

Station	Distance	Years of Data	QMED AM	L-CV	L-Skew	Discordancy
27073 (Brompton Beck @ Snainton Ings)	1.086	40	0.816	0.215	0.019	1.186
27051 (Crimple @ Burn Bridge)	1.309	48	4.544	0.22	0.145	0.367
76011 (Coal Burn @ Coalburn)	1.495	43	1.84	0.167	0.303	1.112
26016 (Gypsey Race @ Kirby Grindalythe)	1.639	23	0.101	0.312	0.258	0.149
25019 (Leven @ Easby)	1.689	42	5.384	0.339	0.385	0.231
45816 (Haddeo @ Upton)	1.986	27	3.456	0.299	0.416	0.747
36010 (Bumpstead Brook @ Broad Green)	2.045	53	7.5	0.379	0.172	1.654
49005 (Bolingey Stream @ Bolingey Cocks Bridge)	2.084	10	5.972	0.257	0.135	2.898
27010 (Hodge Beck @ Bransdale Weir)	2.085	41	9.42	0.224	0.293	0.356
26014 (Water Forlornes @ Driffield)	2.168	22	0.431	0.299	0.119	0.656
44008 (South Winterbourne @ Winterbourne Steepleton)	2.172	41	0.448	0.408	0.318	0.572

⁶ Level 1 Strategic Flood Risk Assessment (JBA Consulting, July 2019)

⁷ Level 2 Strategic Flood Risk Assessment (JBA Consulting, May 2020)

⁸ Preliminary Flood Risk Assessment (Leicestershire County Council, June 2011)

⁹ Local Flood Risk Management Strategy (Leicestershire County Council, August 2015)

28033 (Dove @ Hollinsclough)	2.313	45	4.15	0.225	0.373	0.864
7011 (Black Burn @ Pluscarden Abbey)	2.322	7	5.205	0.544	0.571	2.59
41020 (Bevern Stream @ Clappers Bridge)	2.386	51	13.66	0.205	0.171	0.725
39033 (Winterbourne Stream @ Bagnor)	2.43	58	0.401	0.342	0.382	0.893
Total		551				
Weighted Means				0.288	0.263	
H2 value	2.6958					
Goodness of Fit	Generalised Logistic			General Extreme Value		
	0.1471			-1.1661		

Table 6.2: Final Pooling Group (before permeable adjustment): HIN_PG

Station	Distance	Years of Data	QMED AM	L-CV	L-Skew	Discordancy
27073 (Brompton Beck @ Snainton Ings)	1.086	40	0.816	0.215	0.019	1.383
27051 (Crimple @ Burn Bridge)	1.309	48	4.544	0.22	0.145	0.363
76011 (Coal Burn @ Coalburn)	1.495	43	1.84	0.167	0.303	1.187
26016 (Gypsey Race @ Kirby Grindalythe)	1.639	23	0.101	0.312	0.258	0.22
25019 (Leven @ Easby)	1.689	42	5.384	0.339	0.385	0.799
45816 (Haddeo @ Upton)	1.986	27	3.456	0.299	0.416	1.048
36010 (Bumpstead Brook @ Broad Green)	2.045	53	7.5	0.379	0.172	1.761
49005 (Bolingey Stream @ Bolingey Cocks Bridge)	2.084	10	5.972	0.257	0.135	2.629
27010 (Hodge Beck @ Bransdale Weir)	2.085	41	9.42	0.224	0.293	0.277
26014 (Water Forlornes @ Driffield)	2.168	22	0.431	0.299	0.119	0.629
28033 (Dove @ Hollinsclough)	2.313	45	4.15	0.225	0.373	0.712
41020 (Bevern Stream @ Clappers Bridge)	2.386	51	13.66	0.205	0.171	0.915
39033 (Winterbourne Stream @ Bagnor)	2.43	58	0.401	0.342	0.382	1.076
Total		503				
Weighted Means				0.266	0.249	
H2 value	2.3818					
Goodness of Fit	Generalised Logistic			General Extreme Value		
	-0.1544			-1.3816		

Table 6.3: Permeable Adjusted L-CV and L-Skew

Station	Adjusted L-CV	Adjusted L-Skew
27073 (Brompton Beck @ Snainton Ings)	0.199	0.055

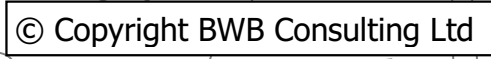
Station	Adjusted L-CV	Adjusted L-Skew
26016 (Gypsy Race @ Kirby Grindalythe)	0.283	0.313
26014 (Water Forlomes @ Driffield)	0.287	0.099

Appendix 3: Table of Hydraulic Structures

Network ID, Cross Section ID	Model Details	Photograph/Survey Section
UOW001_01475	Description: Normandy Way Culvert NGR: 442537, 295644 Domain: 1D ESTRY Unit Type: Circular Conduit (Double) Dimensions: 2 x 0.5m dia Upstream Invert Level: 108.71m AOD and 108.72m AOD Downstream Invert Level: Not surveyed Length: 81m Manning's N: 0.015 Blockage: 0% Spill/Bypass: Modelled in 2D domain	
UOW001_01321	Description: Access Bridge NGR: 442464, 295789 Domain: 1D ESTRY Unit Type: Irregular Culvert Upstream Invert Level: 106.88m AOD Downstream Invert Level: 106.67m AOD Length: 6m Manning's N: 0.020 Blockage: 0% Spill/Bypass: Modelled in 2D domain	
R2_00278	Description: Normandy Way Culvert NGR: 441843, 295428 Domain: 1D ESTRY Unit Type: Circular Culvert (Double) Dimensions: 2 x 0.45m dia Upstream Invert Level: Not surveyed Downstream Invert Level: 105.48 AOD Length: 306m Manning's N: 0.015 Blockage: 0% Spill/Bypass: Modelled in 2D domain	

Network ID, Cross Section ID	Model Details	Photograph/Survey Section
R2_00145	Description: Access Track Culvert NGR: 441766, 295522 Domain: 1D ESTRY Unit Type: Circular Culvert Dimensions: 0.6m dia Upstream Invert Level: 104.57m AOD Downstream Invert Level: 104.53m AOD Length: 7m Manning's N: 0.015 Blockage: 0% Spill/Bypass: Modelled in 2D domain	
R3_00139	Description: Access Track Culvert NGR: 441747, 295516 Domain: 1D ESTRY Unit Type: Circular Culvert Dimensions: 0.5m dia Upstream Invert Level: 103.89m AOD Downstream Invert Level: 103.88m AOD Length: 7m Manning's N: 0.015 Blockage: 0% Spill/Bypass: Modelled in 2D domain	
R4_00000	Description: Stoke Road Culvert NGR: 441697, 295593 Domain: 1D ESTRY Unit Type: Irregular Culvert Upstream Invert Level: 103.41m AOD Downstream Invert Level: Not surveyed Length: 19m (assumed) Manning's N: 0.020 Blockage: 0% Spill/Bypass: Modelled in 2D domain	

Appendix 4: Model Schematic



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- 1D Domain
- 1D Flow / Time (QT) Inflows
- 1D Head / Time (HT) Boundary
- 1D Sewer Manholes
- 1D Pipes / Culverts
- 1D Open Watercourse
- 2D Domain
- 2D Head / Flow (HQ) Boundary
- 2D Watercourse Channel
- Illustrative Site Boundary

P01	24.03.22	Preliminary Issue	MB	AP
Rev	Date	Details of issue / revision	Drw	Rev

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Project Title

Land East of Stoke Road and North of Normandy Way (A47), Hinckley

Drawing Title

Baseline Hydraulic Model Schematic

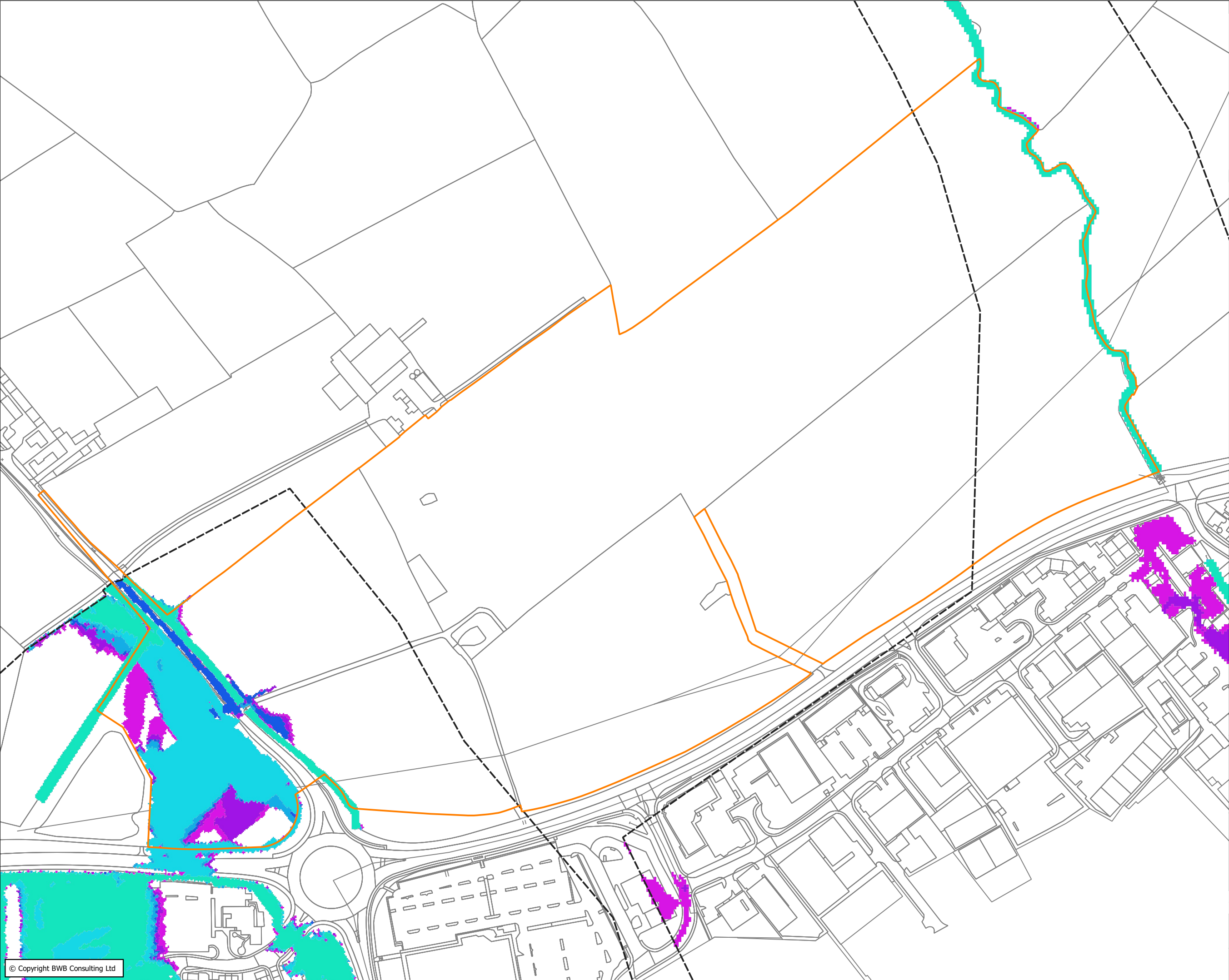
Drawn:	M. Brambani		Reviewed:	A. Petrakis	
BWB Ref:	210683	Date:	24.03.22	Scale@A1:	1:3000

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
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Appendix 5: Baseline Flood Maps



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Key

Illustrative Site Location

Model Domain

Baseline Flood Extents

- 1 in 20-Year
- 1 in 100-Year
- 1 in 100-Year + 22%
- 1 in 100-year + 30%
- 1 in 100-Year + 51%
- 1 in 1000-Year

P02	20.04.22	MINOR AMENDMENTS	LR	MB
P01	23.03.22	PRELIMINARY ISSUE	LR	MB
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Drawing Title

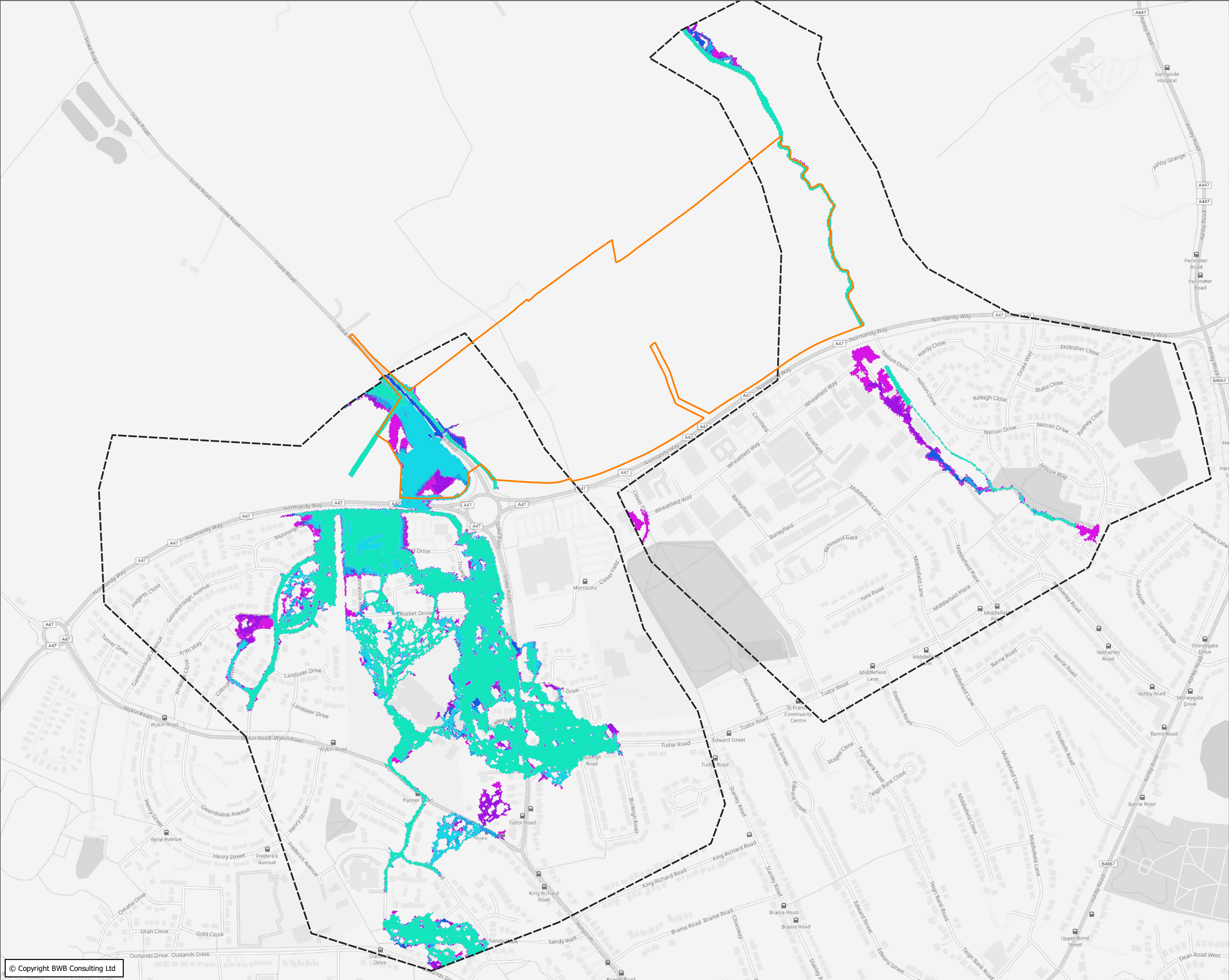
**Baseline Model Flood
Extents**

Drawn:	L. Reeves	Reviewed:	M. Bramani
BWB Ref:	210683	Date:	23.03.22
Scale@A3:	1:2750		

Drawing Status

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Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
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Key

Illustrative Site Location

Model Domain

Baseline Flood Extents

- 1 in 20-Year
- 1 in 100-Year
- 1 in 100-Year + 22%
- 1 in 100-Year + 30%
- 1 in 100-Year + 51%
- 1 in 1000-Year

Rev	Date	Details of issues/ revision	Drw	Rev
P02	20.04.22	MINOR AMENDMENTS	LR	MB
P01	23.03.22	PRELIMINARY ISSUE	LR	MB

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**Baseline Model Flood
Extents**

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Key

- Illustrative Site Location
- Model Domain
- Modelled Flood Depths (m)**
 - <= 0.25
 - 0.25 - 0.50
 - 0.50 - 0.75
 - 0.75 - 1.00
 - 1.00 - 1.25
 - > 1.25

Rev	Date	Details of issues/ revision	Drw	Rev
P02	20.04.22	MINOR AMENDMENTS	LR	MB
P01	23.03.22	PRELIMINARY ISSUE	LR	MB

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Drawing Title
**Baseline Modelled Flood
Depths: 1 in 20-Year**

Drawn:	L. Reeves	Reviewed:	M. Bramani
BWB Ref:	210683	Date:	23.03.22
		Scale@A3:	1:2750

Drawing Status			
PRELIMINARY			
Project - Originator - Zone - Level - Type - Role - Number			
Status			
Rev			
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S2 P02			



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Key

 Illustrative Site Location

 Model Domain

Modelled Flood Depths (m)

 <= 0.25

 0.25 - 0.50

 0.50 - 0.75

 0.75 - 1.00

 1.00 - 1.25

 > 1.25

P02	20.04.22	MINOR AMENDMENTS	LR	MB	
P01	23.03.22	PRELIMINARY ISSUE	LR	MB	
Rev	Date	Details of issues/ revision	Drw	Rev	

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Drawing Title

**Baseline Modelled Flood
Depths: 1 in 100-Year**

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BWB Ref:	210683	Date:	23.03.22
Scale@A3:	1:2750		
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Project - Originator - Zone - Level - Type - Role - Number			Status Rev
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Key

Illustrative Site Location

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

P02	20.04.22	MINOR AMENDMENTS	LR	MB	
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Drawing Title

**Baseline Modelled Flood
Depths: 1 in 100-Year + 22%
Climate Change**

Drawn:	L. Reeves		Reviewed:	M. Brambani	
BWB Ref:	210683	Date:	23.03.22	Scale@A3:	1:2750
Drawing Status					
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Project - Originator - Zone - Level - Type - Role - Number				Status	Rev
HIN-BWB-ZZ-XX-DR-YE-0004				S2	P02



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Illustrative Site Location

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

P02	20.04.22	MINOR AMENDMENTS	LR	MB	
P01	23.03.22	PRELIMINARY ISSUE	LR	MB	
Rev	Date	Details of issues/ revision	Drw	Rev	

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Drawing Title

Baseline Modelled Flood Depths: 1 in 100-Year + 30% Climate Change

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BWB Ref:	210683	Date:	23.03.22	Scale@A3:	1:2750

Drawing Status

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Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
HIN-BWB-ZZ-XX-DR-YE-0005	S2	P02



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Illustrative Site Location

Model Domain

Modelled Flood Depths (m)

<= 0.25

0.25 - 0.50

0.50 - 0.75

0.75 - 1.00

1.00 - 1.25

> 1.25

P02	20.04.22	MINOR AMENDMENTS	LR	MB	
P01	23.03.22	PRELIMINARY ISSUE	LR	MB	
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Drawing Title

**Baseline Modelled Flood
Depths: 1 in 100-Year + 51%
Climate Change**

Drawn:	L. Reeves	Reviewed:	M. Brambani		
BWB Ref:	210683	Date:	23.03.22	Scale@A3:	1:2750

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
HIN-BWB-ZZ-XX-DR-YE-0006	S2	P02



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Key

	Model Domain
---	--------------

P02	20.04.22	MINOR AMENDMENTS	LR	MB	
P01	23.03.22	PRELIMINARY ISSUE	LR	MB	
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Project Title

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Drawing Title

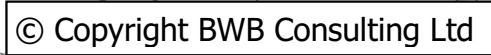
**Baseline Modelled Flood
Depths: 1 in 1000-Year**

Drawn:	L. Reeves	Reviewed:	M. Bramani
BWB Ref:	210683	Date:	23.03.22
Scale@A3:	1:2750		

Drawing Status

PRELIMINARY				
Project - Originator - Zone - Level - Type - Role - Number	Status	Rev		
HIN-BWB-ZZ-XX-DR-YE-0007	S2	P02		

Appendix 6: Proposed Model Schematic



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- 1D Domain
- 1D Flow / Time (QT) Inflows
- 1D Head / Time (HT) Boundary
- 1D Sewer Manholes
- 1D Pipes / Culverts
- 1D Open Watercourse
- 2D Domain
- 2D Head / Flow (HQ) Boundary
- 2D Watercourse Channel
- 2D Proposed Ground Levels - 105.50m AOD
- Illustrative Site Boundary

01	21.04.22	Preliminary Issue	MB	LR
Rev	Date	Details of issue / revision	Drw	Rev

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Project Title

Land East of Stoke Road and North of Normandy Way (A47), Hinckley

Proposed Hydraulic Model Schematic

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WB Ref:	210683	Date:	21.04.22	Scale@A1:	1:3000

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
WIN-BWB-ZZ-XX-DR-YE-0026	S2	P01

Appendix 7: Proposed Flood Maps



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 5. Model not yet peer reviewed.
 6. OS Mapping has been reproduced under the licence number 100022432.
 7. Proposed plans taken from drawing reference: P18-1531-009-1F.

Key

Illustrative Site Location

Model Domain

Proposed Flood Extents

1 in 20-Year

1 in 100-Year

1 in 100-Year + 22%

P01	26.04.22	PRELIMINARY ISSUE	LR	MB	
Rev	Date	Details of issues/ revision	Drw	Rev	

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Client

**Richborough Estates Limited
and Mr & Mrs Adcock**

Project Title

**Land East of Stoke Road and
North of Normandy Way
(A47), Hinckley**

Drawing Title

**Proposed Model Flood
Extents**

Drawn:	L. Reeves		Reviewed:	M. Bramani	
BWB Ref:	210683	Date:	26.04.22	Scale@A3:	1:2750
Drawing Status					
PRELIMINARY					
Project - Originator - Zone - Level - Type - Role - Number				Status	Rev
HIN-BWB-ZZ-XX-DR-YE-0016				S2	P01



- Notes
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 4. Any discrepancies noted on site are to be reported to the engineer immediately.
 5. Model not yet peer reviewed.
 6. OS Mapping has been reproduced under the licence number 100022432.
 7. Proposed plans taken from drawing reference: P18-1531-009-1F.

Key

Illustrative Site Location

Model Domain

Modelled Flood Depths (m)

- ≤ 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

P01	26.04.22	PRELIMINARY ISSUE		LR	MB
Rev	Date	Details of issues/ revision		Drw	Rev

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Project Title

**Land East of Stoke Road and
North of Normandy Way
(A47), Hinckley**

Drawing Title

**Proposed Modelled Flood
Depths: 1 in 20-Year**

Drawn:	L. Reeves	Reviewed:	M. Bramani
BWB Ref:	210683	Date:	26.04.22
Scale:	A3:	1:2750	
Drawing Status			
PRELIMINARY			
Project - Originator - Zone - Level - Type - Role - Number			
HIN-BWB-ZZ-XX-DR-YE-0017			
Status	S2	Rev	P01



- Notes**
1. Do not scale this drawing. All dimensions must be checked/ verified on site. If in doubt ask.
 2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.
 3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.
 4. Any discrepancies noted on site are to be reported to the engineer immediately.
 5. Model not yet peer reviewed.
 6. OS Mapping has been reproduced under the licence number 100022432.
 7. Proposed plans taken from drawing reference: P18-1531-009-1F.

Key

Illustrative Site Location

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

P01	26.04.22	PRELIMINARY ISSUE	LR	MB	
Rev	Date	Details of issues/ revision	Drw	Rev	

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Project Title

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North of Normandy Way
(A47), Hinckley**

Drawing Title

**Proposed Modelled Flood
Depths: 1 in 100-Year**

Drawn:	L. Reeves		Reviewed:	M. Bramani	
BWB Ref:	210683	Date:	26.04.22	Scale@A3:	1:2750
Drawing Status					
PRELIMINARY					
Project - Originator - Zone - Level - Type - Role - Number				Status	Rev
HIN-BWB-ZZ-XX-DR-YE-0018				S2	P01



- Notes
1. Do not scale this drawing. All dimensions must be checked/ verified on site. If in doubt ask.
 2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.
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 4. Any discrepancies noted on site are to be reported to the engineer immediately.
 5. Model not yet peer reviewed.
 6. OS Mapping has been reproduced under the licence number 100022432.
 7. Proposed plans taken from drawing reference: P18-1531-009-1F.

Key

 Illustrative Site Location

 Model Domain

Modelled Flood Depths (m)

 <= 0.25

 0.25 - 0.50

 0.50 - 0.75

 0.75 - 1.00

 1.00 - 1.25

 > 1.25

P02	26.04.22	MINOR AMENDMENTS	LR	MB	
P01	08.04.22	PRELIMINARY ISSUE	LR	MB	
Rev	Date	Details of issues/ revision	Drw	Rev	

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Project Title

**Land East of Stoke Road and
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(A47), Hinckley**

Drawing Title

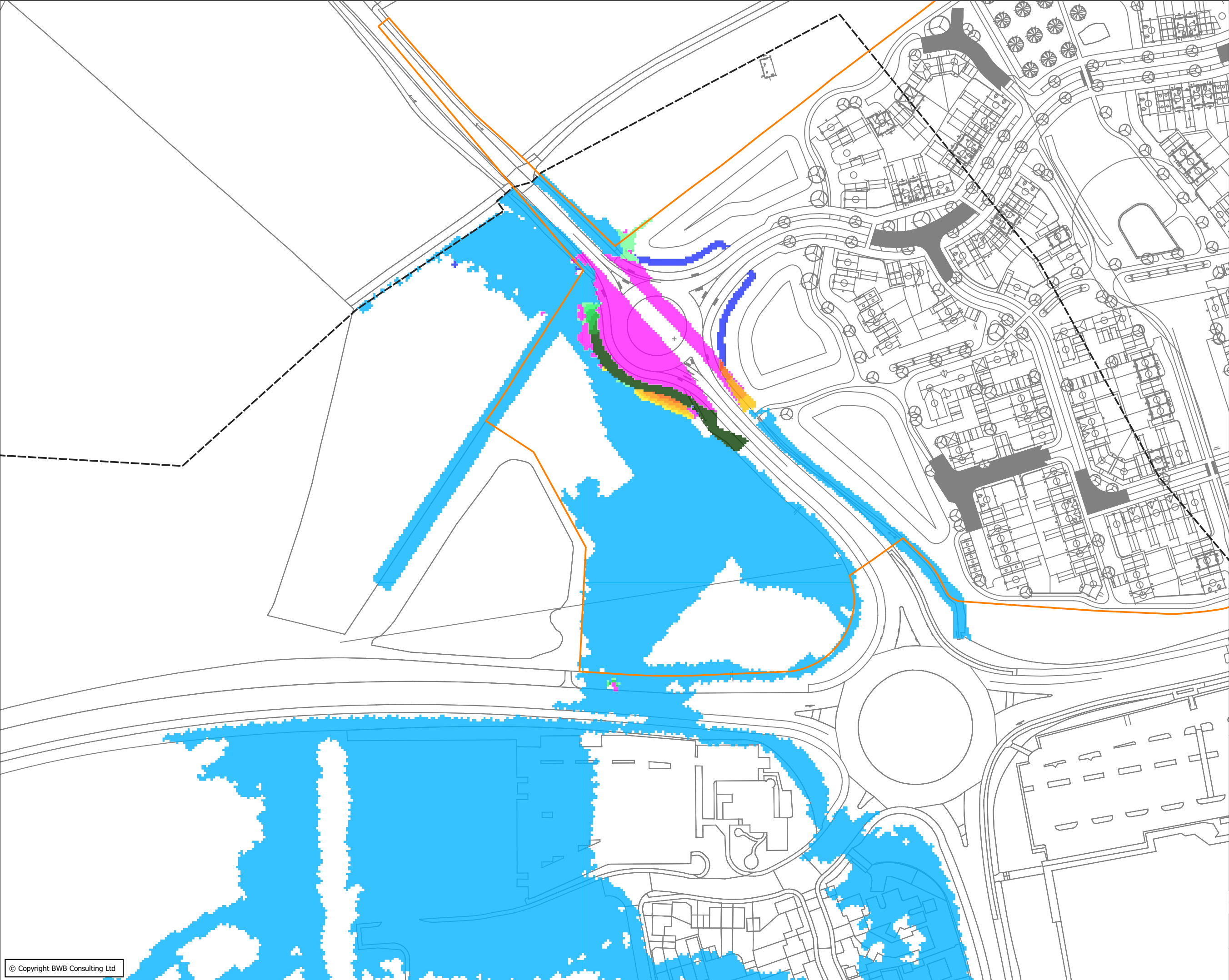
**Proposed Modelled Flood
Depths: 1 in 100-Year + 22%
Climate Change**

Drawn:	L. Reeves	Reviewed:	M. Bramani
BWB Ref:	210683	Date:	08.04.22
		Scale@A3:	1:2750

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
HIN-BWB-ZZ-XX-DR-YE-0015	S2	P02



- Notes
1. Do not scale this drawing. All dimensions must be checked/ verified on site. If in doubt ask.
 2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.
 3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.
 4. Any discrepancies noted on site are to be reported to the engineer immediately.
 5. Model not yet peer reviewed.
 6. OS Mapping has been reproduced under the licence number 100022432.
 7. Proposed plans taken from drawing reference: P18-1531-009-1F.

Key

Illustrative Site Location

Model Domain

Change in Floodplain Extent

Former Wet Areas Now Dry

Former Dry Areas Now Wet

Change in Peak Flood Level (m)

<= -0.125

-0.125 - -0.100

-0.100 - -0.075

-0.075 - -0.050

-0.050 - -0.025

-0.025 - -0.01

-0.01 - 0.01 (No Change)

0.01 - 0.025

0.025 - 0.050

0.050 - 0.075

0.075 - 0.100

0.100 - 0.125

> 0.125

Rev	Date	Details of issues/ revision	Drw	Rev
P02	26.04.22	MINOR AMENDMENTS	LR	MB
P01	08.04.22	PRELIMINARY ISSUE	LR	MB

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Project Title

**Land East of Stoke Road and
North of Normandy Way
(A47), Hinckley**

Drawing Title

**Baseline and Post-
Development Comparative
Analysis: 1 in 100-Year +
22% Climate Change**

Drawn:	L. Reeves	Reviewed:	M. Brambani
BWB Ref:	210683	Date:	08.04.22
Scale@A3:	1:500		

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
HIN-BWB-ZZ-XX-DR-YE-0014	S2	P02

Appendix 8: Sensitivity Tests



- Notes**
1. Do not scale this drawing. All dimensions must be checked/ verified on site. If in doubt ask.
 2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.
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 4. Any discrepancies noted on site are to be reported to the engineer immediately.
 5. Model not yet peer reviewed.
 6. OS Mapping has been reproduced under the licence number 100022432.

Key

Illustrative Site Location

Model Domain

Change in Floodplain Extent

- Former Wet Areas Now Dry
- Former Dry Areas Now Wet

Change in Peak Flood Level (m)

- <= -0.125
- 0.125 - -0.100
- 0.100 - -0.075
- 0.075 - -0.050
- 0.050 - -0.025
- 0.025 - -0.01
- 0.01 - 0.01 (No Change)
- 0.01 - 0.025
- 0.025 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.125
- > 0.125

P02	20.04.22	MINOR AMENDMENTS	LR	MB	
P01	28.03.22	PRELIMINARY ISSUE	LR	MB	
Rev	Date	Details of issues/ revision	Drw	Rev	

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Client

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Project Title

**Land East of Stoke Road and
North of Normandy Way
(A47), Hinckley**

Drawing Title

**Baseline Sensitivity:
Increased Downstream
Boundary (20%) 1 in 100-
Year**

Drawn:	L. Reeves	Reviewed:	M. Bramani		
BWB Ref:	210683	Date:	28.03.22	Scale@A3:	1:3750

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
HIN-BWB-ZZ-XX-DR-YE-0009	S2	P02



Notes

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2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.

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4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. OS Mapping has been reproduced under the licence number 100022432.

Key

Illustrative Site Location

Model Domain

Change in Floodplain Extent

Former Wet Areas Now Dry

Former Dry Areas Now Wet

Change in Peak Flood Level (m)

<= -0.125

-0.125 - -0.100

-0.100 - -0.075

-0.075 - -0.050

-0.050 - -0.025

-0.025 - -0.01

-0.01 - 0.01 (No Change)

0.01 - 0.025

0.025 - 0.050

0.050 - 0.075

0.075 - 0.100

0.100 - 0.125

> 0.125

P02	20.04.22	MINOR AMENDMENTS	LR	MB	
P01	28.03.22	PRELIMINARY ISSUE	LR	MB	
Rev	Date	Details of issues/ revision	Drw	Rev	

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Client

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Project Title

**Land East of Stoke Road and
North of Normandy Way
(A47), Hinckley**

Drawing Title

**Baseline Sensitivity:
Decreased Downstream
Boundary (20%) 1 in 100-
Year**

Drawn:	L. Reeves	Reviewed:	M. Brambani		
BWB Ref:	210683	Date:	28.03.22	Scale@A3:	1:3750

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
HIN-BWB-ZZ-XX-DR-YE-0010	S2	P02



- Notes
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4. Any discrepancies noted on site are to be reported to the engineer immediately.

5. Model not yet peer reviewed.

6. OS Mapping has been reproduced under the licence number 100022432.

Key

Illustrative Site Location

Model Domain

Change in Floodplain Extent

Former Wet Areas Now Dry

Former Dry Areas Now Wet

Change in Peak Flood Level (m)

<= -0.125

-0.125 - -0.100

-0.100 - -0.075

-0.075 - -0.050

-0.050 - -0.025

-0.025 - -0.01

-0.01 - 0.01 (No Change)

0.01 - 0.025

0.025 - 0.050

0.050 - 0.075

0.075 - 0.100

0.100 - 0.125

> 0.125

P02	20.04.22	MINOR AMENDMENTS	LR	MB	
P01	28.03.22	PRELIMINARY ISSUE	LR	MB	
Rev	Date	Details of issues/ revision	Drw	Rev	

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Project Title

Land East of Stoke Road and

North of Normandy Way

(A47), Hinckley

Drawing Title

Baseline Sensitivity:

Increased Roughness (20%)

1 in 100-Year

Drawn:

L. Reeves

Reviewed:

M. Brambani

BWB Ref:

210683

Date:

28.03.22

Scale@A3:

1:3750

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number

Status

Rev

HIN-BWB-ZZ-XX-DR-YE-0011

S2

P02



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 5. Model not yet peer reviewed.
 6. OS Mapping has been reproduced under the licence number 100022432.

Key

Illustrative Site Location

Model Domain

Change in Floodplain Extent

Former Wet Areas Now Dry

Former Dry Areas Now Wet

Change in Peak Flood Level (m)

<= -0.125

-0.125 - -0.100

-0.100 - -0.075

-0.075 - -0.050

-0.050 - -0.025

-0.025 - -0.01

-0.01 - 0.01 (No Change)

0.01 - 0.025

0.025 - 0.050

0.050 - 0.075

0.075 - 0.100

0.100 - 0.125

> 0.125

P02	20.04.22	MINOR AMENDMENTS	LR	MB	
P01	28.03.22	PRELIMINARY ISSUE	LR	MB	
Rev	Date	Details of issues/ revision	Drw	Rev	

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Project Title

**Land East of Stoke Road and
North of Normandy Way
(A47), Hinckley**

Drawing Title

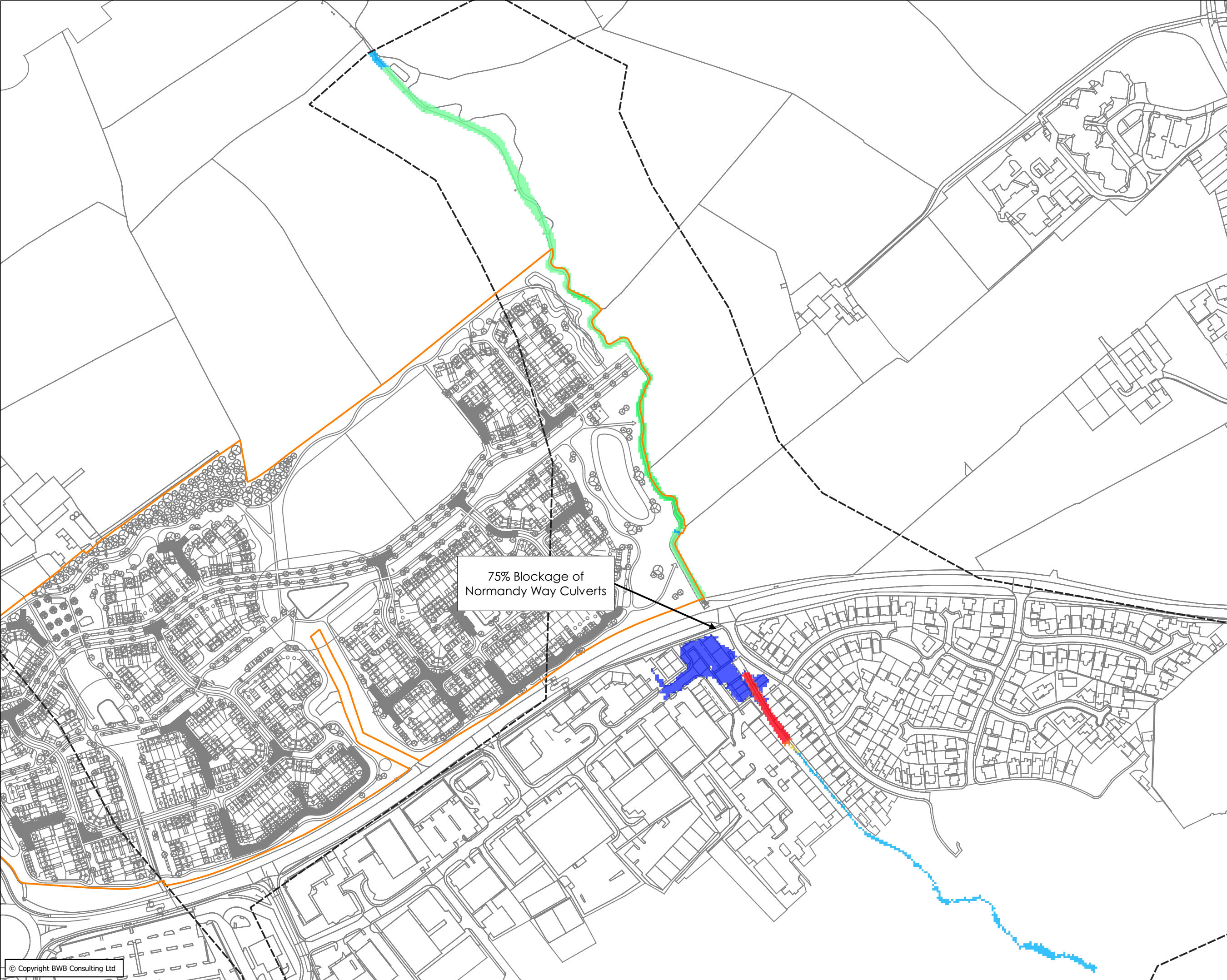
**Baseline Sensitivity:
Decreased Roughness (20%)
1 in 100-Year**

Drawn:	L. Reeves	Reviewed:	M. Bramani
BWB Ref:	210683	Date:	28.03.22
		Scale@A3:	1:3750

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
HIN-BWB-ZZ-XX-DR-YE-0012	S2	P02



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 5. Model not yet peer reviewed.
 6. OS Mapping has been reproduced under the licence number 100022432.
 7. Proposed plans taken from drawing reference: P18-1531-009-1F.

Key

Illustrative Site Location

Model Domain

Change in Floodplain Extent

Former Wet Areas Now Dry

Former Dry Areas Now Wet

Change in Peak Flood Level (m)

<= -0.125

-0.125 - -0.100

-0.100 - -0.075

-0.075 - -0.050

-0.050 - -0.025

-0.025 - -0.01

-0.01 - 0.01 (No Change)

0.01 - 0.025

0.025 - 0.050

0.050 - 0.075

0.075 - 0.100

0.100 - 0.125

> 0.125

P01	26.04.22	PRELIMINARY ISSUE		LR	MB
Rev	Date	Details of issues/ revision		Drw	Rev

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Project Title

**Land East of Stoke Road and
North of Normandy Way
(A47), Hinckley**

Drawing Title

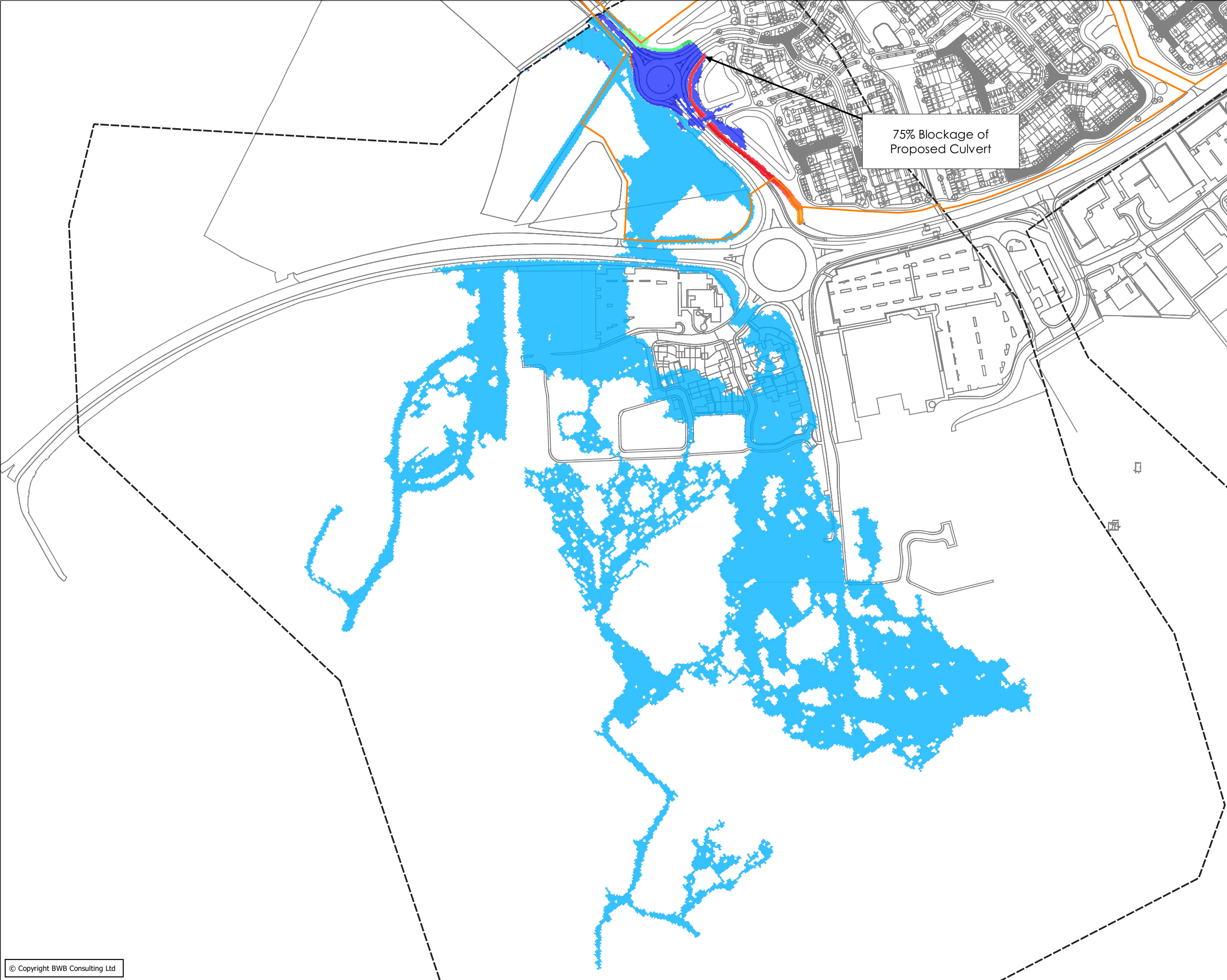
**Post-Development
Sensitivity: Normandy Way
Blockage (75% Blockage of
Each Opening) 1 in 100-Year**

Drawn:	L. Reeves	Reviewed:	M. Bramani
BWB Ref:	210683	Date:	26.04.22
		Scale@A3:	1:3250

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
HIN-BWB-ZZ-XX-DR-YE-0019	S2	P01



- Notes**
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 5. Model not yet peer reviewed.
 6. OS Mapping has been reproduced under the licence number 100022432.
 7. Proposed plans taken from drawing reference: P18-1531-009-1F.

- Key**
- Illustrative Site Location
 - Model Domain
 - Change in Floodplain Extent**
 - Former Wet Areas Now Dry
 - Former Dry Areas Now Wet
 - Change in Peak Flood Level (m)**
 - <= -0.125
 - 0.125 - -0.100
 - 0.100 - -0.075
 - 0.075 - -0.050
 - 0.050 - -0.025
 - 0.025 - -0.01
 - 0.01 - 0.01 (No Change)
 - 0.01 - 0.025
 - 0.025 - 0.050
 - 0.050 - 0.075
 - 0.075 - 0.100
 - 0.100 - 0.125
 - > 0.125

P01	26.04.22	PRELIMINARY ISSUE		LR	MB
Rev	Date	Details of issues/ revision		Drw	Rev

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Project Title

**Land East of Stoke Road and
North of Normandy Way
(A47), Hinckley**

Drawing Title

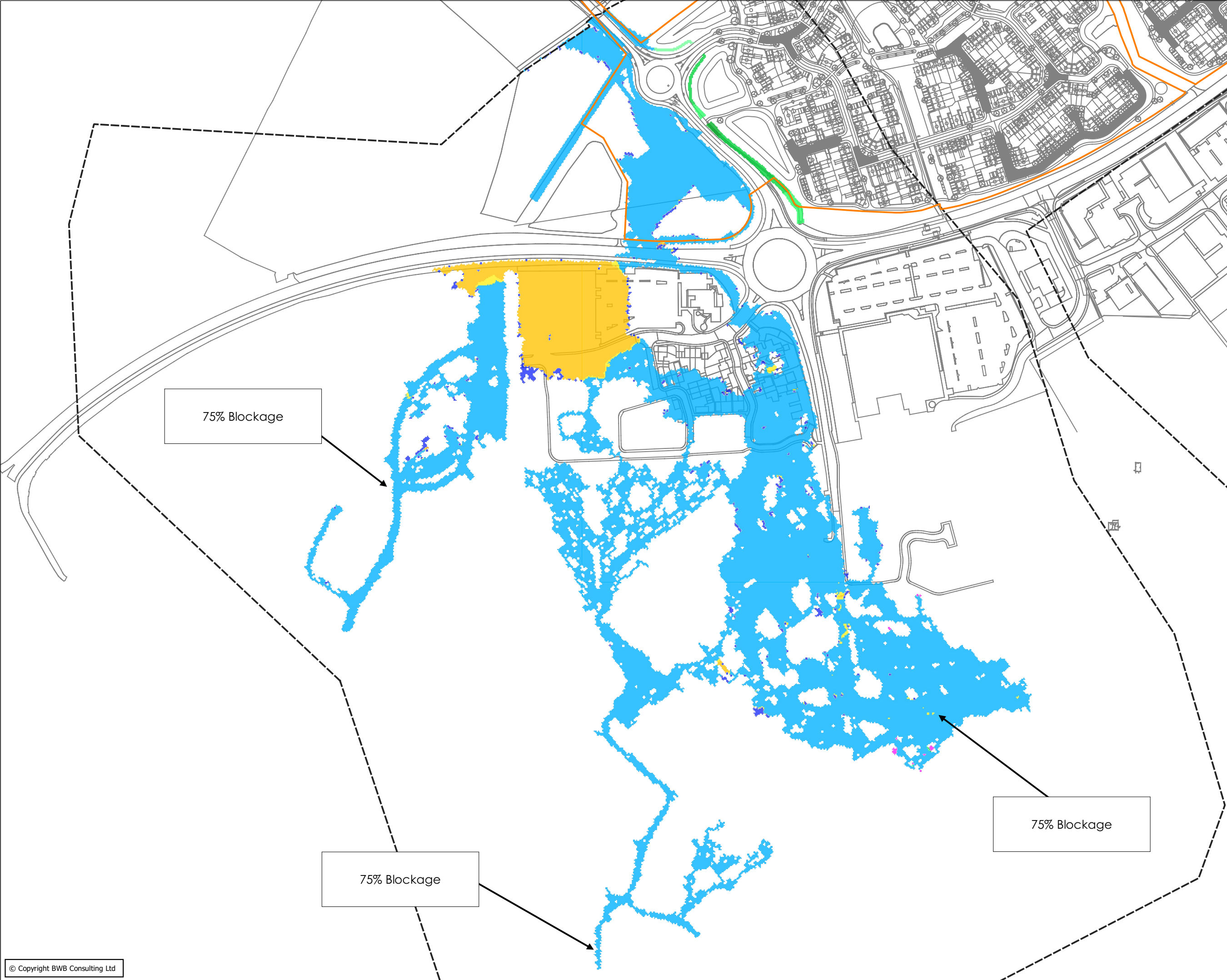
**Post-Development
Sensitivity: Proposed
Culvert (75% Blockage) 1 in
100-Year**

Drawn:	L. Reeves	Reviewed:	M. Bramani		
BWB Ref:	210683	Date:	26.04.22	Scale@A3:	1:3250

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
HIN-BWB-ZZ-XX-DR-YE-0021	S2	P01



- Notes**
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 4. Any discrepancies noted on site are to be reported to the engineer immediately.
 5. Model not yet peer reviewed.
 6. OS Mapping has been reproduced under the licence number 100022432.
 7. Proposed plans taken from drawing reference: P18-1531-009-1F.

Key

Illustrative Site Location

Model Domain

Change in Floodplain Extent

Former Wet Areas Now Dry

Former Dry Areas Now Wet

Change in Peak Flood Level (m)

<= -0.125

-0.125 - -0.100

-0.100 - -0.075

-0.075 - -0.050

-0.050 - -0.025

-0.025 - -0.01

-0.01 - 0.01 (No Change)

0.01 - 0.025

0.025 - 0.050

0.050 - 0.075

0.075 - 0.100

0.100 - 0.125

> 0.125

P01	26.04.22	PRELIMINARY ISSUE		LR	MB
Rev	Date	Details of issues/ revision		Drw	Rev

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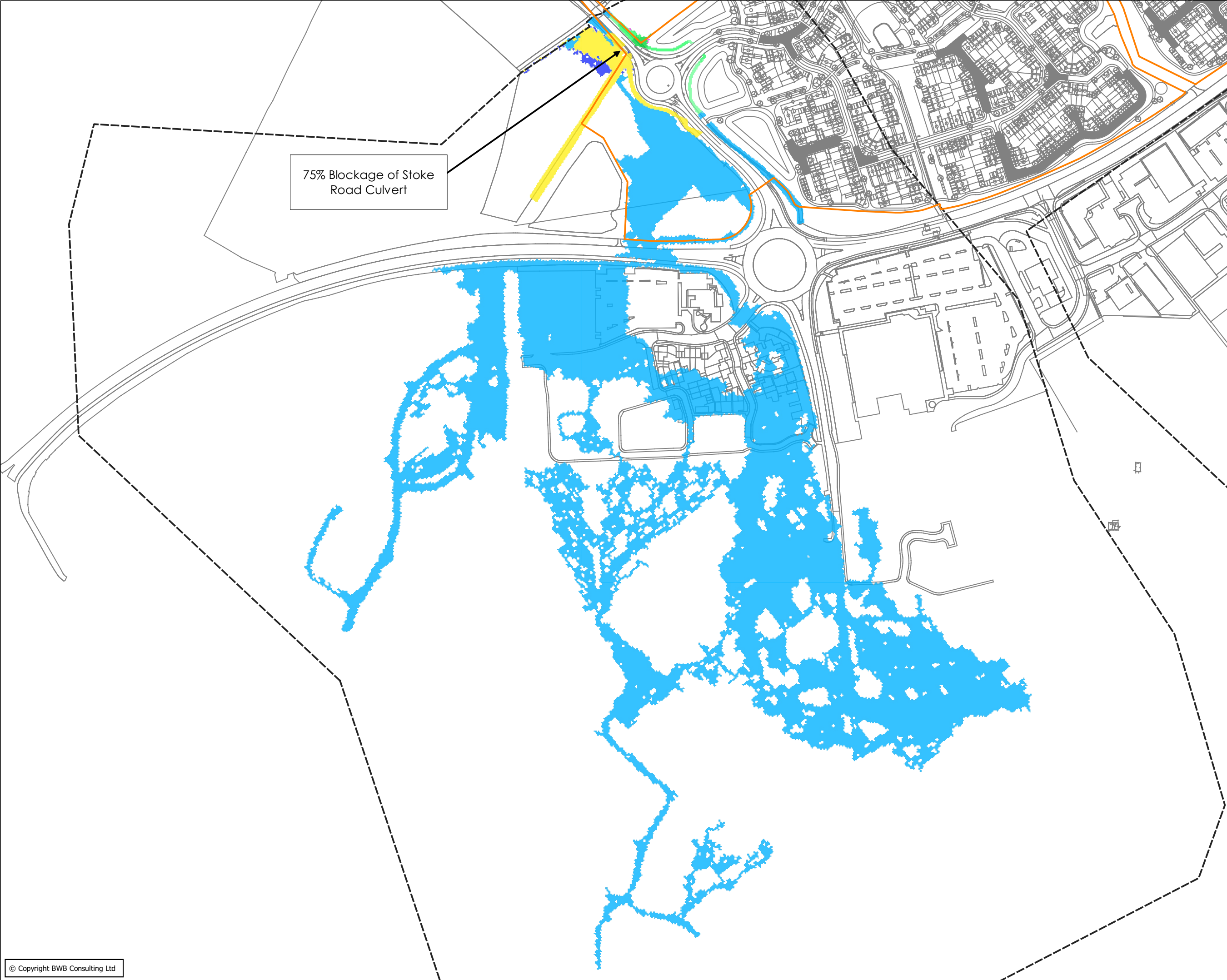
**Land East of Stoke Road and
North of Normandy Way
(A47), Hinckley**

Drawing Title

**Post-Development
Sensitivity: Sewer Network
(75% Blockage of Multiple
Pipes) 1 in 100-Year**

Drawn:	L. Reeves	Reviewed:	M. Bramani
BWB Ref:	210683	Date:	26.04.22
		Scale@A3:	1:3250

Drawing Status						
PRELIMINARY						
Project - Originator - Zone - Level - Type - Role - Number					Status	Rev
HIN-BWB-ZZ-XX-DR-YE-0020					S2	P01



75% Blockage of Stoke Road Culvert

- Notes**
1. Do not scale this drawing. All dimensions must be checked/ verified on site. If in doubt ask.
 2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.
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 4. Any discrepancies noted on site are to be reported to the engineer immediately.
 5. Model not yet peer reviewed.
 6. OS Mapping has been reproduced under the licence number 100022432.
 7. Proposed plans taken from drawing reference: P18-1531-009-1F.

Key

Illustrative Site Location

Model Domain

Change in Floodplain Extent

Former Wet Areas Now Dry

Former Dry Areas Now Wet

Change in Peak Flood Level (m)

<= -0.125

-0.125 - -0.100

-0.100 - -0.075

-0.075 - -0.050

-0.050 - -0.025

-0.025 - -0.01

-0.01 - 0.01 (No Change)

0.01 - 0.025

0.025 - 0.050

0.050 - 0.075

0.075 - 0.100

0.100 - 0.125

> 0.125

P01	26.04.22	PRELIMINARY ISSUE		LR	MB
Rev	Date	Details of issues/ revision		Drw	Rev

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Client

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Project Title

**Land East of Stoke Road and
North of Normandy Way
(A47), Hinckley**

Drawing Title

**Post-Development
Sensitivity: Stoke Road
Culvert (75% Blockage) 1 in
100-Year**

Drawn:	L. Reeves	Reviewed:	M. Bramani
BWB Ref:	210683	Date:	26.04.22
		Scale@A3:	1:3250

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
HIN-BWB-ZZ-XX-DR-YE-0022	S2	P01



- Notes
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 4. Any discrepancies noted on site are to be reported to the engineer immediately.
 5. Model not yet peer reviewed.
 6. OS Mapping has been reproduced under the licence number 100022432.
 7. Proposed plans taken from drawing reference: P18-1531-009-1F.

- Key
- Illustrative Site Location
 - Model Domain
 - Flood Hazard**
 - Low (<0.75)
 - Moderate (0.75-1.25)
 - Significant (1.25-2.00)
 - Extreme (>2.00)

P01	26.04.22	PRELIMINARY ISSUE	LR	MB	
Rev	Date	Details of issues/ revision	Drw	Rev	

Issues & Revisions

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Client

**Richborough Estates Limited
and Mr & Mrs Adcock**

Project Title

**Land East of Stoke Road and
North of Normandy Way
(A47), Hinckley**

Drawing Title

**Post-Development Hazard
Rating: Proposed Culvert
(75% Blockage) 1 in 100-Year**

Drawn:	L. Reeves	Reviewed:	M. Bramani
BWB Ref:	210683	Date:	26.04.22
		Scale@A3:	1:2750

Drawing Status				
PRELIMINARY				
Project - Originator - Zone - Level - Type - Role - Number	Status	Rev		
HIN-BWB-ZZ-XX-DR-YE-0023	S2	P01		



A **CAF** GROUP COMPANY

Appendix 2: Detailed Pooling Group Information

Table 5.1: Default Pooling Group: UOW001

Station	Distance	Years of Data	QMED AM	Deurbanised L-CV	Deurbanised L-Skew	Discordancy
27073 (Brompton Beck @ Snainton Ings)	1.086	41	0.82	0.213	0.005	1.466
27051 (Crimple @ Burn Bridge)	1.309	49	4.564	0.218	0.142	0.413
76011 (Coal Burn @ Coalburn)	1.495	44	1.84	0.168	0.302	1.052
26016 (Gypsy Race @ Kirby Grindalythe)	1.639	24	0.103	0.304	0.24	0.172
25019 (Leven @ Easby)	1.689	43	5.677	0.335	0.372	0.22
45816 (Haddeo @ Upton)	1.986	28	3.352	0.294	0.423	0.7
36010 (Bumpstead Brook @ Broad Green)	2.045	54	7.545	0.374	0.167	1.414
49005 (Bolingey Stream @ Bolingey Cocks Bridge)	2.084	11	5.777	0.263	0.206	3.182
27010 (Hodge Beck @ Bransdale Weir)	2.085	41	9.42	0.224	0.293	0.337
26014 (Water Forlomes @ Driffield)	2.168	23	0.437	0.316	0.163	0.441
44008 (South Winterbourne @ Winterbourne Steepleton)	2.172	30	0.496	0.422	0.289	1.107
28033 (Dove @ Hollinsclough)	2.313	46	4.138	0.223	0.379	0.891
7011 (Black Burn @ Pluscarden Abbey)	2.322	9	5.205	0.491	0.521	2.076
41020 (Bevern Stream @ Clappers Bridge)	2.386	52	13.78	0.203	0.164	0.737
39033 (Winterbourne Stream @ Bagnor)	2.43	59	0.403	0.338	0.375	0.791
Total		554				
Weighted Means				0.286	0.262	
H2 value	2.8467					
Goodness of Fit	Generalised Logistic		General Extreme Value		Kappa 3	
	0.1192		-1.2797		-0.3465	

Table 1.2: Pooling Group (Permeable Stations Removed): UOW001

Station	Distance	Years of Data	QMED AM	Deurbanised L-CV	Deurbanised L-Skew	Discordancy
27051 (Crimple @ Burn Bridge)	1.309	49	4.564	0.218	0.142	0.413
76011 (Coal Burn @ Coalburn)	1.495	44	1.84	0.168	0.302	1.052
25019 (Leven @ Easby)	1.689	43	5.677	0.335	0.372	0.22
45816 (Haddeo @ Upton)	1.986	28	3.352	0.294	0.423	0.7
36010 (Bumpstead Brook @ Broad Green)	2.045	54	7.545	0.374	0.167	1.414
49005 (Bolingey Stream @ Bolingey Cocks Bridge)	2.084	11	5.777	0.263	0.206	3.182
27010 (Hodge Beck @ Bransdale Weir)	2.085	41	9.42	0.224	0.293	0.337
28033 (Dove @ Hollinsclough)	2.313	46	4.138	0.223	0.379	0.891

41020 (Bevern Stream @ Clappers Bridge)	2.386	52	13.78	0.203	0.164	0.737
Total		368				
Weighted Means				0.255	0.272	
H2 value		1.5663				
Goodness of Fit	Generalised Logistic		General Extreme Value		Kappa 3	
	-0.209		-1.2479		-0.5511	

Table 1.3: Final Pooling Group (Adjusted for Non-Flood Years): UOW001

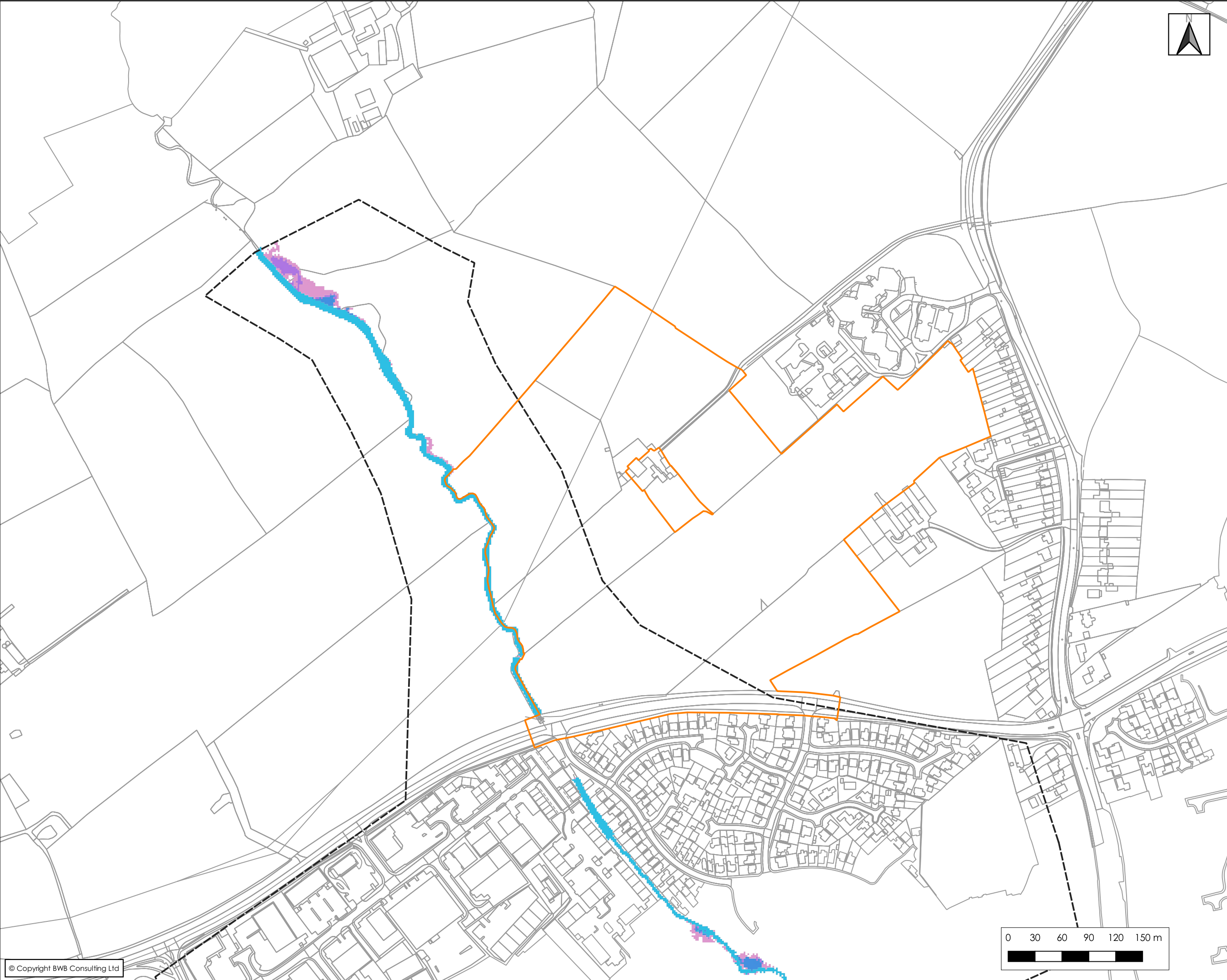
Station	Distance	Years of Data	QMED AM	Deurbanised L-CV	Deurbanised L-Skew	Discordancy
27073 (Brompton Beck @ Snainton Ings)	1.086	41	0.82	0.213	0.005	1.466
27051 (Crimple @ Burn Bridge)	1.309	49	4.564	0.218	0.142	0.413
76011 (Coal Burn @ Coalburn)	1.495	44	1.84	0.168	0.302	1.052
26016 (Gypsy Race @ Kirby Grindalythe)	1.639	24	0.103	0.304	0.24	0.172
25019 (Leven @ Easby)	1.689	43	5.677	0.335	0.372	0.22
45816 (Haddeo @ Upton)	1.986	28	3.352	0.294	0.423	0.7
36010 (Bumpstead Brook @ Broad Green)	2.045	54	7.545	0.374	0.167	1.414
49005 (Bolingey Stream @ Bolingey Cocks Bridge)	2.084	11	5.777	0.263	0.206	3.182
27010 (Hodge Beck @ Bransdale Weir)	2.085	41	9.42	0.224	0.293	0.337
28033 (Dove @ Hollinsclough)	2.313	46	4.138	0.223	0.379	0.891
7011 (Black Burn @ Pluscarden Abbey)	2.322	9	5.205	0.491	0.521	2.076
41020 (Bevern Stream @ Clappers Bridge)	2.386	52	13.78	0.203	0.164	0.737
39033 (Winterbourne Stream @ Bagnor)	2.43	59	0.403	0.338	0.375	0.791
Total		501				
Weighted Means				0.274	0.266	
H2 value		2.184				
Goodness of Fit	Generalised Logistic		General Extreme Value		Kappa 3	
	-0.549		-1.7631		-0.9517	

Table 1.4: Permeable Adjusted L-CV and L-Skew

Station	Adjusted L-CV	Adjusted L-Skew
27073 (Brompton Beck @ Snainton Ings)	0.199	0.036
26016 (Gypsy Race @ Kirby Grindalythe)	0.276	0.296
36010 (Bumpstead Brook @ Broad Green)	0.310	0.240

Station	Adjusted L-CV	Adjusted L-Skew
7011 (Black Burn @ Pluscarden Abbey)	0.492	0.507
39033 (Winterbourne Stream @ Bagnor)	0.308	0.443

Appendix 3: Baseline Floodplain Maps



- Notes**
1. Do not scale this drawing. All dimensions must be checked/ verified on site. If in doubt ask.
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 3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.
 4. Any discrepancies noted on site are to be reported to the engineer immediately.
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Key

Illustrative Site Location

Model Domain

Baseline Floodplain Extents

1 in 30-Year

1 in 100-Year

1 in 100-Year + 22%CC

1 in 1000-Year

P04	04.03.24	RED LINE BOUNDARY UPDATED	SR	LR
P03	11.01.24	RED LINE BOUNDARY UPDATED	SR	LR
P02	06.11.23	RED LINE BOUNDARY UPDATED	LR	MB
P01	04.08.23	PRELIMINARY ISSUE	LR	MB
Rev	Date	Details of issues/ revision	Drw	Rev

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Richborough

Project Title

Land North of A47 Normandy Way and West of A447 Ashby Road, Hinckley

Drawing Title

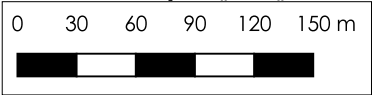
Baseline Model Floodplain Extents

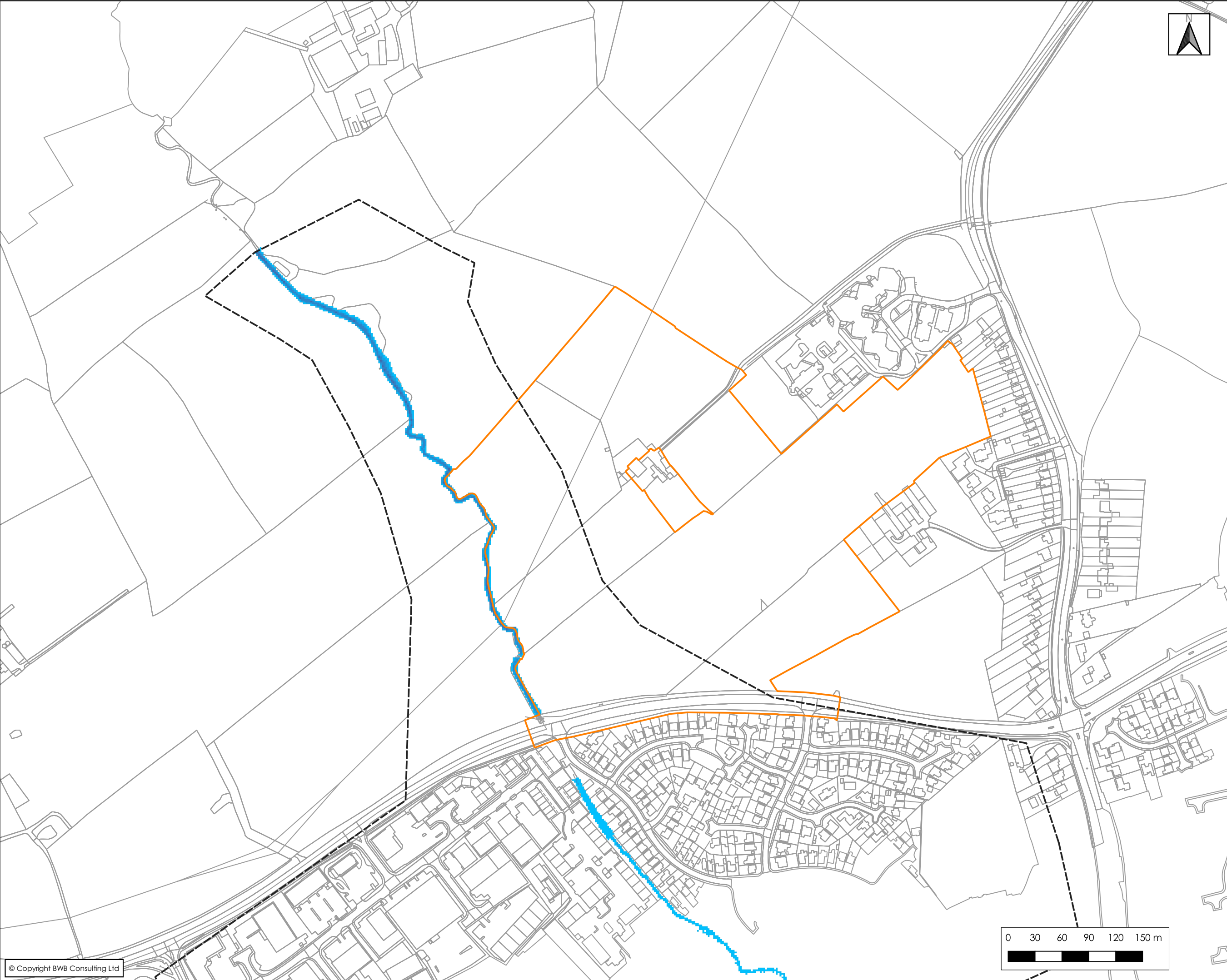
Drawn:	L. Reeves	Reviewed:	M. Bramani
BWB Ref:	232746	Date:	04.08.23
		Scale@A3:	1:3,833

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
HN2-BWB-ZZ-XX-DR-YE-0001	S2	P04





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Key

Illustrative Site Location

Model Domain

Modelled Flood Depths (m)

≤ 0.25

0.25 - 0.50

0.50 - 0.75

0.75 - 1.00

1.00 - 1.25

> 1.25

P04	04.03.24	RED LINE BOUNDARY UPDATED	SR	LR
P03	11.01.24	RED LINE BOUNDARY UPDATED	SR	LR
P02	06.11.23	RED LINE BOUNDARY UPDATED	LR	MB
P01	04.08.23	PRELIMINARY ISSUE	LR	MB
Rev	Date	Details of issues/ revision	Drw	Rev

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Client

Richborough

Project Title

Land North of A47 Normandy Way and West of A447 Ashby Road, Hinckley

Drawing Title

Baseline Modelled Flood Depths: 1 in 30-Year

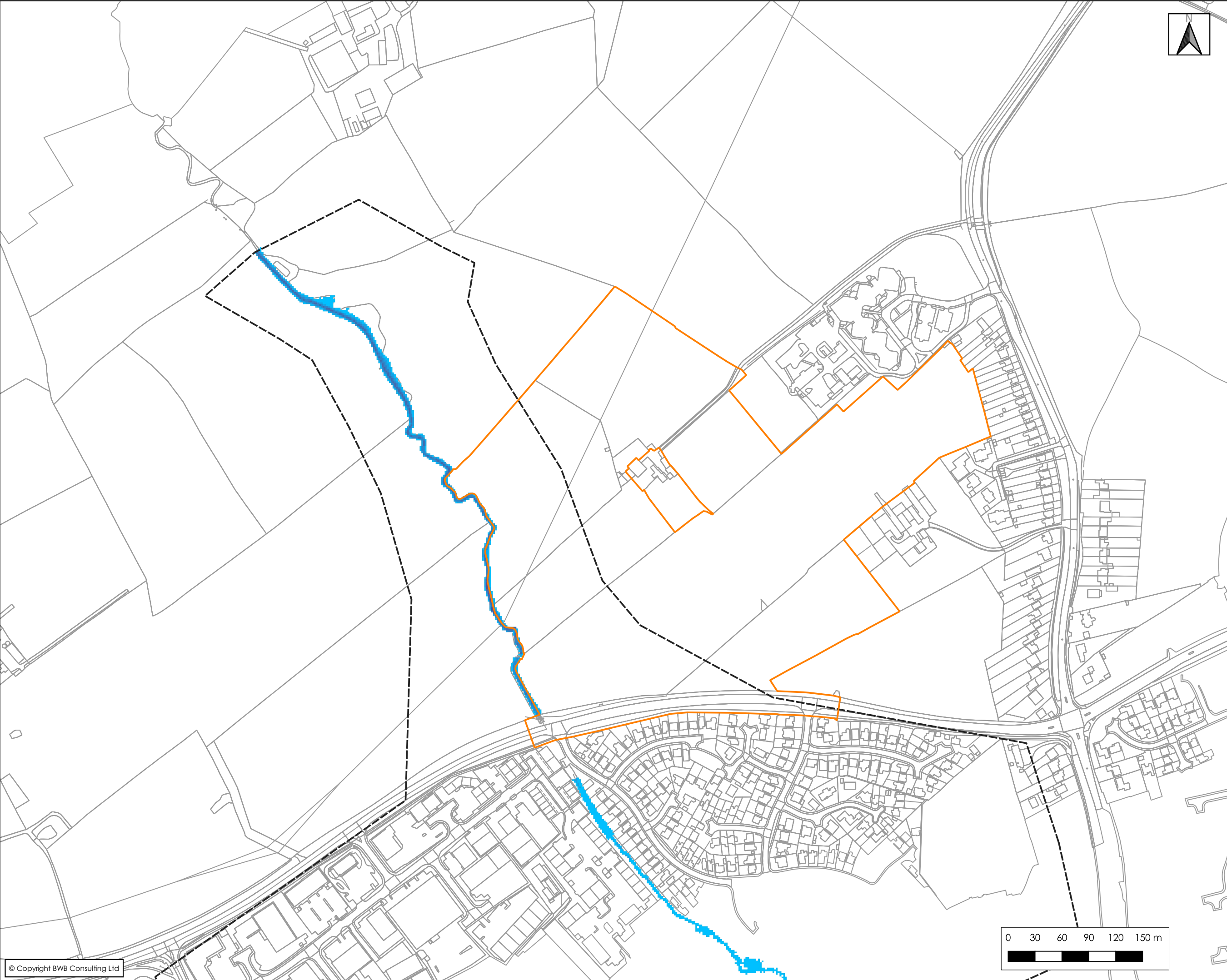
Drawn:	L. Reeves	Reviewed:	M. Bramani
BWB Ref:	232746	Date:	04.08.23
		Scale@A3:	1:3,833

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
HN2-BWB-ZZ-XX-DR-YE-0002	S2	P04





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 4. Any discrepancies noted on site are to be reported to the engineer immediately.
 5. Model not yet peer reviewed.
 6. Contains OS data © Crown copyright (2024) licence number 100022432.

Key

Illustrative Site Location

Model Domain

Modelled Flood Depths (m)

- <= 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

P04	04.03.24	RED LINE BOUNDARY UPDATED	SR	LR
P03	11.01.24	RED LINE BOUNDARY UPDATED	SR	LR
P02	06.11.23	RED LINE BOUNDARY UPDATED	LR	MB
P01	04.08.23	PRELIMINARY ISSUE	LR	MB
Rev	Date	Details of issues/ revision	Drw	Rev

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Richborough

Project Title

Land North of A47 Normandy Way and West of A447 Ashby Road, Hinckley

Drawing Title

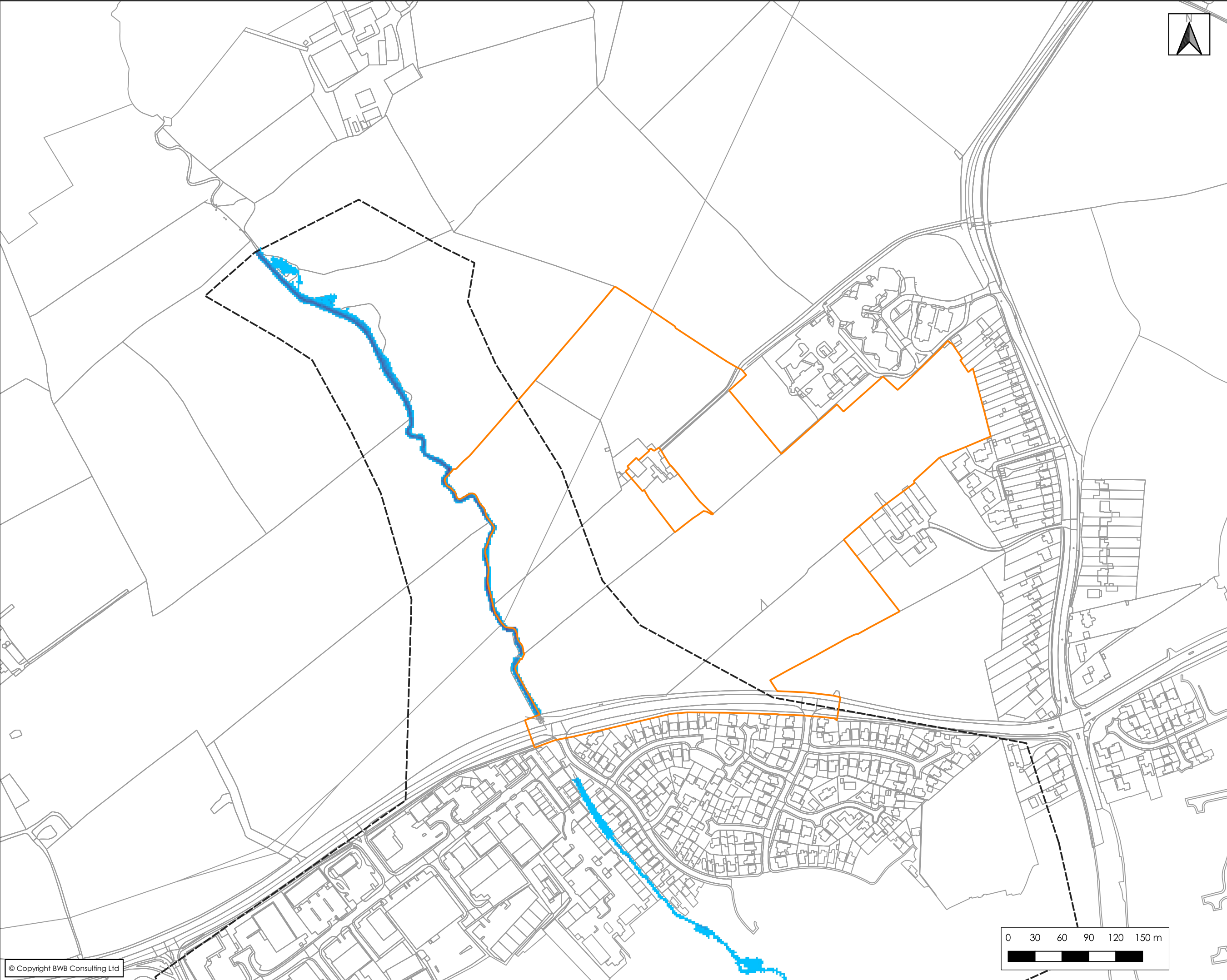
Baseline Modelled Flood Depths: 1 in 100-Year

Drawn:	L. Reeves	Reviewed:	M. Bramani
BWB Ref:	232746	Date:	04.08.23
		Scale@A3:	1:3,833

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
HN2-BWB-ZZ-XX-DR-YE-0003	S2	P04



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Key

Illustrative Site Location

Model Domain

Modelled Flood Depths (m)

≤ 0.25

0.25 - 0.50

0.50 - 0.75

0.75 - 1.00

1.00 - 1.25

> 1.25

P04	04.03.24	RED LINE BOUNDARY UPDATED	SR	LR
P03	11.01.24	RED LINE BOUNDARY UPDATED	SR	LR
P02	06.11.23	RED LINE BOUNDARY UPDATED	LR	MB
P01	04.08.23	PRELIMINARY ISSUE	LR	MB
Rev	Date	Details of issues/ revision	Drw	Rev

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Richborough

Project Title

Land North of A47 Normandy Way and West of A447 Ashby Road, Hinckley

Drawing Title

Baseline Modelled Flood Depths: 1 in 100-Year + 22%CC

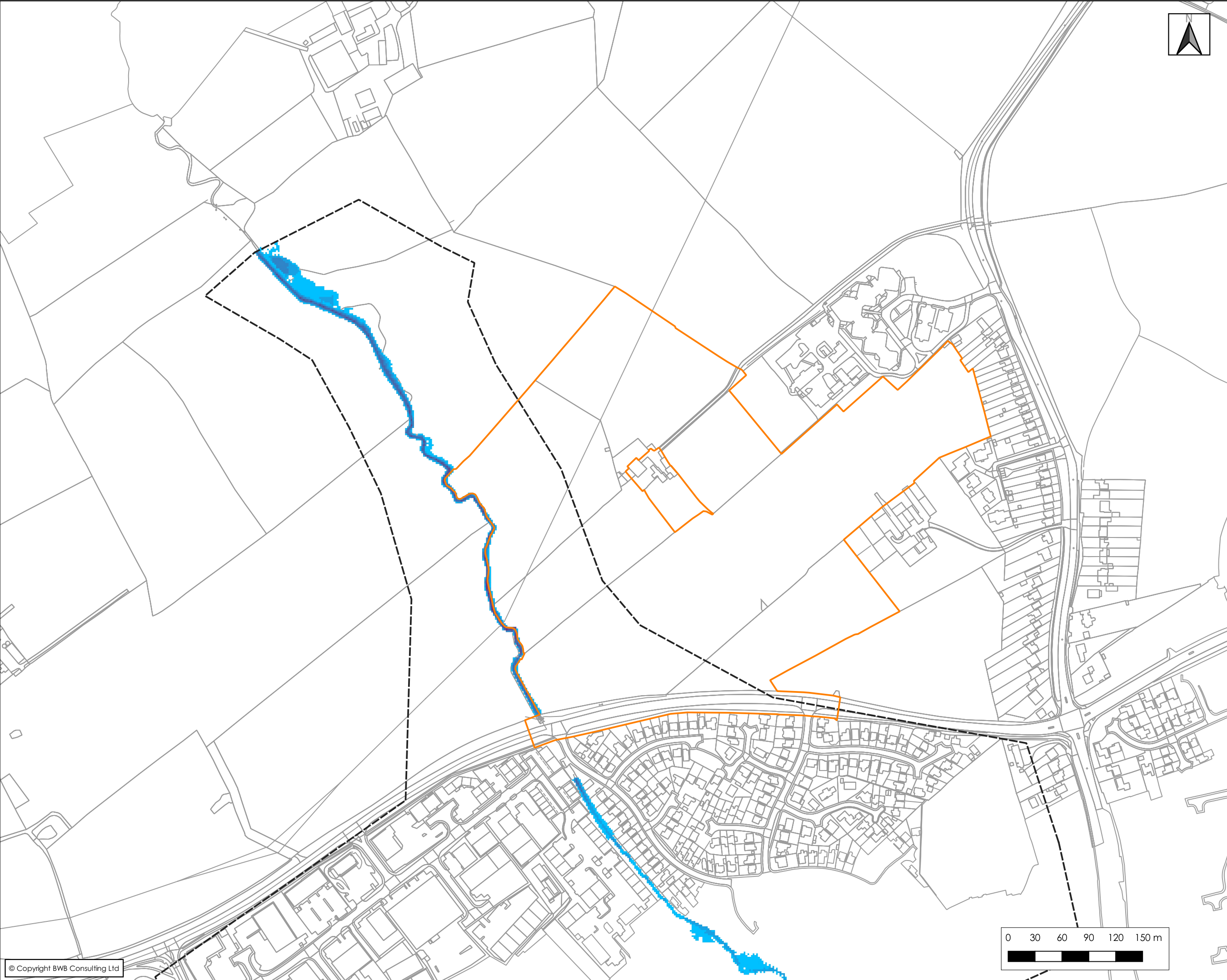
Drawn:	L. Reeves	Reviewed:	M. Bramani
BWB Ref:	232746	Date:	04.08.23
		Scale@A3:	1:3,833

Drawing Status

PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
HN2-BWB-ZZ-XX-DR-YE-0004	S2	P04





- Notes**
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 5. Model not yet peer reviewed.
 6. Contains OS data © Crown copyright (2024) licence number 100022432.

Key

 Illustrative Site Location

 Model Domain

Modelled Flood Depths (m)

 ≤ 0.25

 0.25 - 0.50

 0.50 - 0.75

 0.75 - 1.00

 1.00 - 1.25

 > 1.25

P04	04.03.24	RED LINE BOUNDARY UPDATED	SR	LR
P03	11.01.24	RED LINE BOUNDARY UPDATED	SR	LR
P02	06.11.23	RED LINE BOUNDARY UPDATED	LR	MB
P01	04.08.23	PRELIMINARY ISSUE	LR	MB
Rev	Date	Details of issues/ revision	Drw	Rev

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Project Title

Land North of A47 Normandy Way and West of A447 Ashby Road, Hinckley

Drawing Title

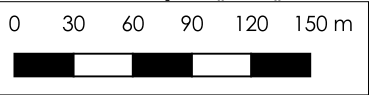
Baseline Modelled Flood Depths: 1 in 1000-Year

Drawn:	L. Reeves	Reviewed:	M. Bramani
BWB Ref:	232746	Date:	04.08.23
		Scale@A3:	1:3,833

Drawing Status

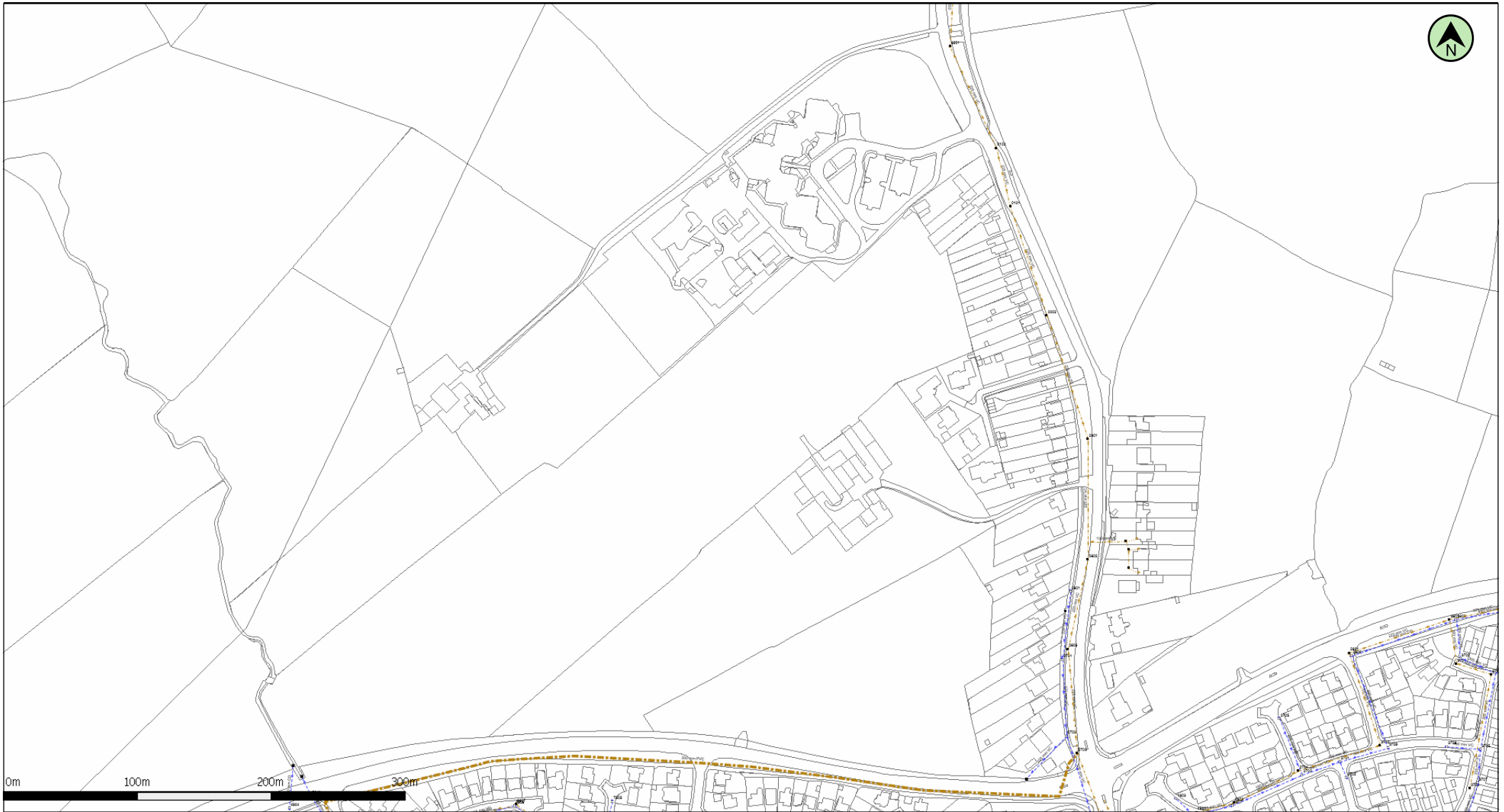
PRELIMINARY

Project - Originator - Zone - Level - Type - Role - Number	Status	Rev
HN2-BWB-ZZ-XX-DR-YE-0005	S2	P04





Appendix 5: Severn Trent Water Sewer Records



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Date: 05/07/23

Scale: 1:4032

Map Centre: 442842,295986

Data updated: 14/06/23

Wastewater Plan A4

Do not scale off this map. The plan and any information supplied with it is furnished as a general guide, is only valid at the date of issue and no warranty as to its correctness is given or implied. In particular this plan and any information shown on it must not be relied upon in the event of any development or works (including but not limited to excavations) in the vicinity of SEVERN TRENT WATER assets or for the purposes of determining the suitability of a point of connection to the sewerage or distribution systems. Reproduction by permission of Ordnance Survey on behalf of HMSO. ©Crown Copyright and database rights 2023. All rights reserved. Ordnance Survey licence number 100031673. Document users other than SEVERN TRENT WATER business users are advised that this document is provided for reference purpose only and is subject to copyright, therefore, no further copies should be made from it.

Public Foul Gravity/Lateral Drain		Highway Drain		Manhole Foul	
Public Combined Gravity/Lateral Drain		Overflow Pipe		Manhole Surface	
Public Surface Water Gravity/Lateral Drain		Disposal Pipe		Abandoned Pipe	
Pressure Foul		Culverted Water Course		Chamber	
Pressure Combined		Pumping Station			
Pressure Surface Water		Fitting			

Section 104 sewers are shown in green
Private sewers are shown in magenta

corinna.haill@bwbconsulting.com



GENERAL CONDITIONS AND PRECAUTIONS TO BE TAKEN WHEN CARRYING OUT WORK ADJACENT TO SEVERN TRENT WATER'S APPARATUS

Please ensure that a copy of these conditions is passed to your representative and/or your contractor on site. If any damage is caused to Severn Trent Water Limited (STW) apparatus (defined below), the person, contractor or subcontractor responsible must inform STW immediately on:

0800 783 4444 (24 hours)

- a) These general conditions and precautions apply to the public sewerage, water distribution and cables in ducts including (but not limited to) sewers which are the subject of an Agreement under Section 104 of the Water Industry Act 1991 (a legal agreement between a developer and STW, where a developer agrees to build sewers to an agreed standard, which STW will then adopt); mains installed in accordance with an agreement for the self-construction of water mains entered into with STW and the assets described at condition b) of these general conditions and precautions. Such apparatus is referred to as "STW Apparatus" in these general conditions and precautions.
- b) Please be aware that due to The Private Sewers Transfer Regulations June 2011, the number of public sewers has increased, but many of these are not shown on the public sewer record. However, some idea of their positions may be obtained from the position of inspection covers and their existence must be anticipated.
- c) On request, STW will issue a copy of the plan showing the approximate locations of STW Apparatus although in certain instances a charge will be made. The position of private drains, private sewers and water service pipes to properties are not normally shown but their presence must be anticipated. This plan and the information supplied with it is furnished as a general guide only and STW does not guarantee its accuracy.
- d) STW does not update these plans on a regular basis. Therefore the position and depth of STW Apparatus may change and this plan is issued subject to any such change. Before any works are carried out, you should confirm whether any changes to the plan have been made since it was issued.
- e) The plan must not be relied upon in the event of excavations or other works in the vicinity of STW Apparatus. It is your responsibility to ascertain the precise location of any STW Apparatus prior to undertaking any development or other works (including but not limited to excavations).
- f) No person or company shall be relieved from liability for loss and/or damage caused to STW Apparatus by reason of the actual position and/or depths of STW Apparatus being different from those shown on the plan.

In order to achieve safe working conditions adjacent to any STW Apparatus the following should be observed:

1. All STW Apparatus should be located by hand digging prior to the use of mechanical excavators.
2. All information set out in any plans received from us, or given by our staff at the site of the works, about the position and depth of the mains, is approximate. Every possible precaution should be taken to avoid damage to STW Apparatus. You or your contractor must ensure the safety of STW Apparatus and will be responsible for the cost of repairing any loss and/or damage caused (including without limitation replacement parts).
3. Water mains are normally laid at a depth of 900mm. No records are kept of customer service pipes which are normally laid at a depth of 750mm; but some idea of their positions may be obtained from the position of stop tap covers and their existence must be anticipated.

4. During construction work, where heavy plant will cross the line of STW Apparatus, specific crossing points must be agreed with STW and suitably reinforced where required. These crossing points should be clearly marked and crossing of the line of STW Apparatus at other locations must be prevented.
5. Where it is proposed to carry out piling or boring within 20 metres of any STW Apparatus, STW should be consulted to enable any affected STW Apparatus to be surveyed prior to the works commencing.
6. Where excavation of trenches adjacent to any STW Apparatus affects its support, the STW Apparatus must be supported to the satisfaction of STW. Water mains and some sewers are pressurised and can fail if excavation removes support to thrust blocks to bends and other fittings.
7. Where a trench is excavated crossing or parallel to the line of any STW Apparatus, the backfill should be adequately compacted to prevent any settlement which could subsequently cause damage to the STW Apparatus. In special cases, it may be necessary to provide permanent support to STW Apparatus which has been exposed over a length of the excavation before backfilling and reinstatement is carried out. There should be no concrete backfill in contact with the STW Apparatus.
8. No other apparatus should be laid along the line of STW Apparatus irrespective of clearance. Above ground apparatus must not be located within a minimum of 3 metres either side of the centre line of STW Apparatus for smaller sized pipes and 6 metres either side for larger sized pipes without prior approval. No manhole or chamber shall be built over or around any STW Apparatus.
9. A minimum radial clearance of 300 millimetres should be allowed between any plant or equipment being installed and existing STW Apparatus. We reserve the right to increase this distance where strategic assets are affected.
10. Where any STW Apparatus coated with a special wrapping is damaged, even to a minor extent, STW must be notified and the trench left open until the damage has been inspected and the necessary repairs have been carried out. In the case of any material damage to any STW Apparatus causing leakage, weakening of the mechanical strength of the pipe or corrosion-protection damage, the necessary remedial work will be recharged to you.
11. It may be necessary to adjust the finished level of any surface boxes which may fall within your proposed construction. Please ensure that these are not damaged, buried or otherwise rendered inaccessible as a result of the works and that all stop taps, valves, hydrants, etc. remain accessible and operable. Minor reduction in existing levels may result in conflict with STW Apparatus such as valve spindles or tops of hydrants housed under the surface boxes. Checks should be made during site investigations to ascertain the level of such STW Apparatus in order to determine any necessary alterations in advance of the works.
12. With regard to any proposed resurfacing works, you are required to contact STW on the number given above to arrange a site inspection to establish the condition of any STW Apparatus in the nature of surface boxes or manhole covers and frames affected by the works. STW will then advise on any measures to be taken, in the event of this a proportionate charge will be made.
13. You are advised that STW will not agree to either the erection of posts, directly over or within 1.0 metre of valves and hydrants,
14. No explosives are to be used in the vicinity of any STW Apparatus without prior consultation with STW.

TREE PLANTING RESTRICTIONS

There are many problems with the location of trees adjacent to sewers, water mains and other STW Apparatus and these can lead to the loss of trees and hence amenity to the area which many people may have become used to. It is best if the problem is not created in the first place. Set out below are the recommendations for tree planting in close proximity to public sewers, water mains and other STW Apparatus.

15. Please ensure that, in relation to STW Apparatus, the mature root systems and canopies of any tree planted do not and will not encroach within the recommended distances specified in the notes below.
16. Both Poplar and Willow trees have extensive root systems and should not be planted within 12 metres of a sewer, water main or other STW Apparatus.

17. The following trees and those of similar size, be they deciduous or evergreen, should not be planted within 6 metres of a sewer, water main or other STW Apparatus. E.g. Ash, Beech, Birch, most Conifers, Elm, Horse Chestnut, Lime, Oak, Sycamore, Apple and Pear. Asset Protection Statements Updated May2014

18. STW personnel require a clear path to conduct surveys etc. No shrubs or bushes should be planted within 2 metre of the centre line of a sewer, water main or other STW Apparatus.

19. In certain circumstances, both STW and landowners may wish to plant shrubs/bushes in close proximity to a sewer, water main or other STW Apparatus for screening purposes. The following are shallow rooting and are suitable for this purpose: Blackthorn, Broom, Cotoneaster, Elder, Hazel, Laurel, Privet, Quickthorn, Snowberry, and most ornamental flowering shrubs.

